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400F/FL
AC VOLTMETER

OPERATING AND SERVICE MANUAL

HEWLETT hp PACKARD

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

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For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

OPERATING AND SERVICE MANUAL

(HP PART NO. 00400-90005)

MODEL 400F/FL
AC VOLTMETER

SERIALS PREFIXED: 734-

Appendix C, Manual Backdating Changes, adapts this manual to serials prefixed 617-.

P. O. Box 301, Loveland, Colorado, 80537 U. S. A.

Printed: JAN 1968

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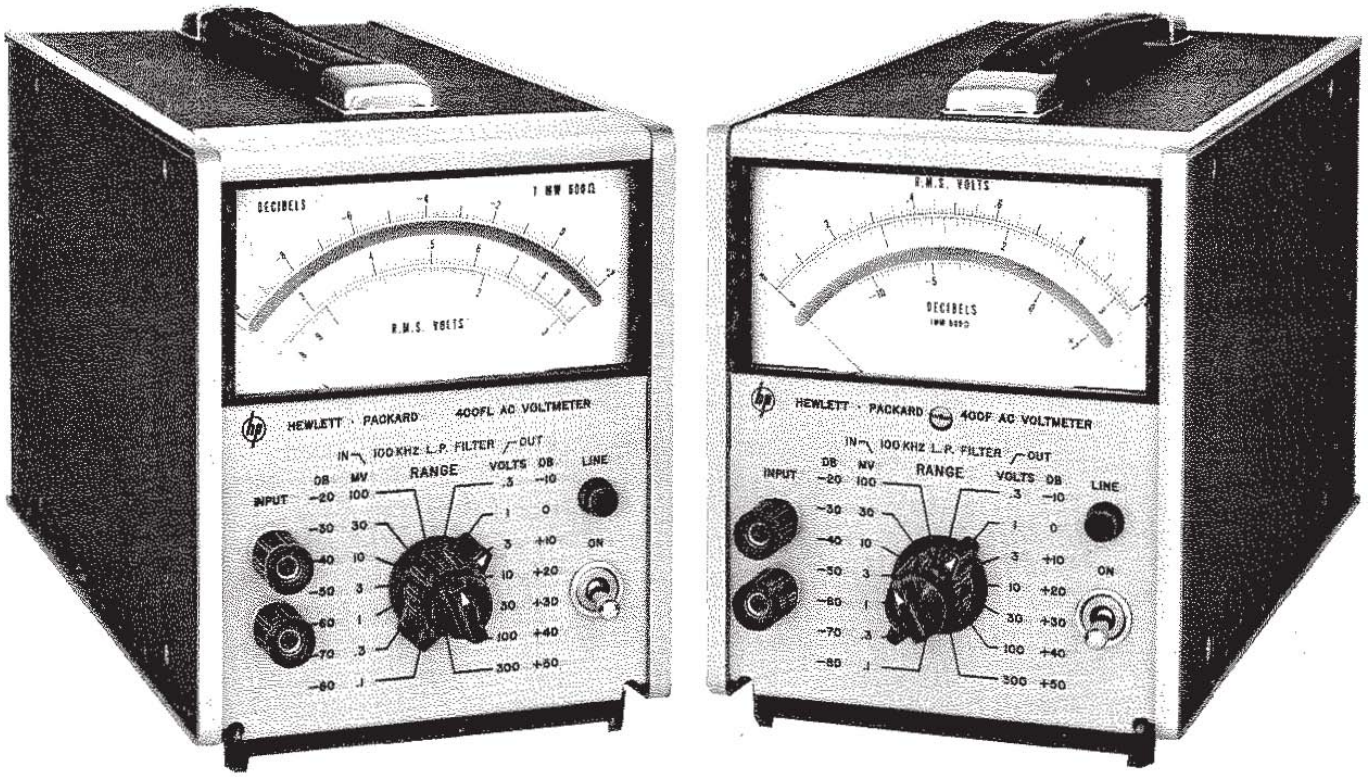


Figure 1-1. Model 400F/FL AC Voltmeter

Table 1-1. Specifications

-hp- Model 400F/FL	-hp- Model 400F/FL
Voltage Range: 100 μV to 300 V full scale, 14 ranges in 1, 3, 10 sequence. Frequency Range: 20 Hz to 4 MHz. Calibration: Responds to absolute average value of applied signal, calibrated in rms volts. Noise Referred to Input: (1000 ohm termination) RANGE / Filter In / Filter Out 300 μV to 300 V / < 5 μV / < 30 μV 100 μV / < 5 μV / < 15 μV Input Impedance: 10 megohms shunted by 25 pF on the 100 μV - 300 mV ranges and 10 megohms shunted by 10 pF on the 1 V - 300 V ranges. Amplifier AC Output: 1 V rms open circuit for full scale meter indication; output impedance 600 ohms, 20 Hz to 4 MHz. Meter Response: <0.7 seconds after application of signal.	Recovery From Overload: < 2 seconds for 80 dB overload. AC Power: 115 or 230 volts ± 10%, 50 to 1000 Hz, 5 watts. External Battery Operation: Terminals are provided on rear panel; positive and negative voltages between 35 V and 55 V are required. Current drain from each voltage is approximately 45 mA. Temperature Range: 0 to +55°C. Weight: Net: 6 lbs. (2,7 kg). Shipping: 9 lbs. (4 kg). Dimensions: 6-1/2" high, 5-1/8" wide, 11" deep (165,1 x 130,2 x 279,4 mm).

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The -hp- Models 400F and 400FL are versatile ac voltmeters and dB meters. Both models can be used as wideband amplifiers. The Model 400F is primarily intended for voltage measurements, whereas the Model 400FL is primarily a dB meter. However, both meters indicate both volts and dB. The 400F has a linear ac scale with a logarithmic dB scale underneath, and the 400FL has a linear dB scale with a logarithmic ac scale underneath. Since the difference in scales is the only difference between the two instruments, this manual will use the term 400F/FL in reference to both instruments.

1-3. Figure 1-1 shows both the Model 400F and the Model 400FL. Table 1-1 is a list of specifications.

1-4. OPTION (400F ONLY).

1-5. Option 01 is a standard -hp- Model 400F AC Voltmeter which has a dB scale that reads from -15 to +2 instead of from -12 to +2. The dB scale is placed at the top of the meter face for better resolution.

1-6. INSTRUMENT AND MANUAL IDENTIFATION.

1-7. Hewlett-Packard instruments are identified by a two-section, eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 400F/FL described in this manual.

1-8. If a letter prefixes the serial number, the instrument was manufactured outside the United States.

1-9. BACKDATING INFORMATION.

1-10. Appendix C contains backdating information that adapts this manual to instruments with serials prefixed 617.

Table 1-1. Specifications (Cont'd)

MODEL 400F
Accuracy: ± (% Full Scale + % Reading)

300 μV TO 300 V RANGES

Frequency	20 Hz	40 Hz	100 Hz	1 MHz	2 MHz	4 MHz
	±(2 + 2)	±(1 + 1)	± (1/2 + 1/2)	± (1 + 1)	±(2 + 2)	

100 μV RANGE

Frequency	30 Hz	60 Hz	100 kHz	500 kHz
	±(2 + 2)	±(1 + 1)	±1	+0 -7

MODEL 400FL
Accuracy: ± % Reading

300 μV TO 300 V RANGES

Frequency	20 Hz	40 Hz	100 Hz	1 MHz	2 MHz	4 MHz
	±4	±2	±1	±2	±4	

100 μV RANGE

Frequency	30 Hz	60 Hz	100 kHz	500 kHz
	±4	±2	+1 -8	

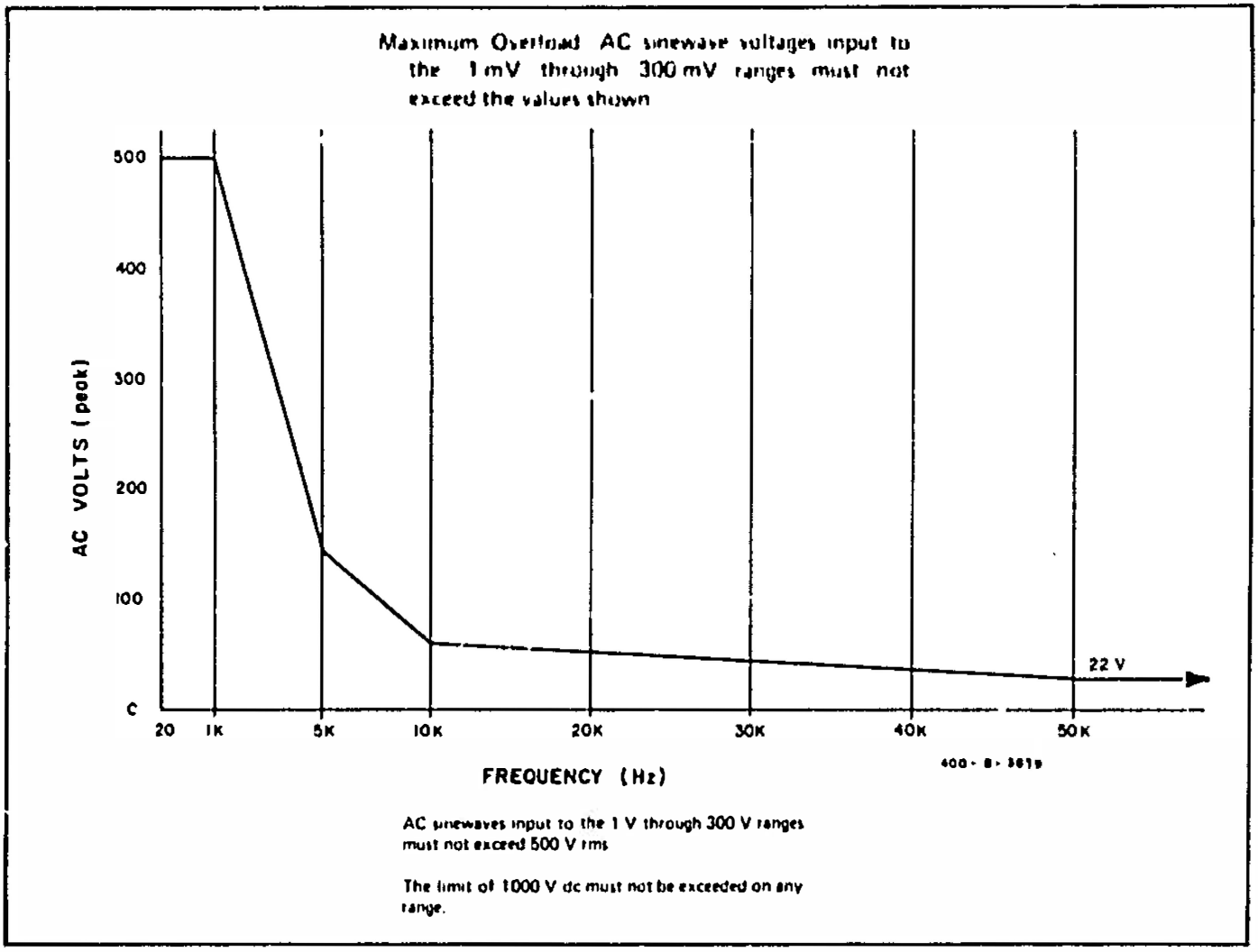


Table 1-2. Performance Characteristics.

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for the installation and shipping of the Model 400F and 400FL voltmeters. Included are initial inspection procedures, power and grounding requirements, installation information, and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5. If there is damage or deficiency, see the warranty on the inside front cover of this manual.

2-5. POWER REQUIREMENTS.

2-6. The Model 400F/FL can be operated from any source of 115 or 230 volts at 50 to 1000 cycles or from two 35 to 55 volt batteries connected to the rear panel BATTERY terminals. The 115/230 V slide switch on the rear panel selects the desired line voltage. Power dissipation is 5 watts maximum.

2-7. GROUNDING REQUIREMENTS.

2-8. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. All Hewlett-Packard instruments are equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground wire.

2-9. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

2-10. INSTALLATION.

2-11. The Model 400F/FL is fully transistorized; therefore, no special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 55°C (131°F) or the relative humidity exceeds 95%.

2-12. BENCH MOUNTING.

2-13. The Model 400F/FL is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument.

2-14. RACK MOUNTING.

2-15. The Model 400F/FL may be rack mounted by using an adapter frame (-hp- Part No. 5060-0797). The adapter frame is a rack frame that accepts any combination of submodular units. It can be rack mounted only. For additional information, address inquires to your -hp- Sales and Service Office. (See Appendix B for office locations.)

2-16. COMBINATION MOUNTING.

2-17. The Model 400F/FL may be mounted in combination with other submodular units by using a Combining Case (-hp- Model 1051A or 1052A). The Combining Case is a full-module unit which accepts various combinations of submodular units. Being a full-module unit, it can be bench or rack mounted and is analogous to any full-module instrument.

2-18. REPACKAGING FOR SHIPMENT.

2-19. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-20 if the original container is to be used; 2-21 if it is not. If you have any questions, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished; include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number, serial number, and serial number prefix.

2-20. If original container is to be used, proceed as follows:

a. Place instrument in original container if available. If original container is not available, one can be purchased from your nearest -hp- Sales and Service Office.

b. Ensure that container is well sealed with strong tape or metal bands.

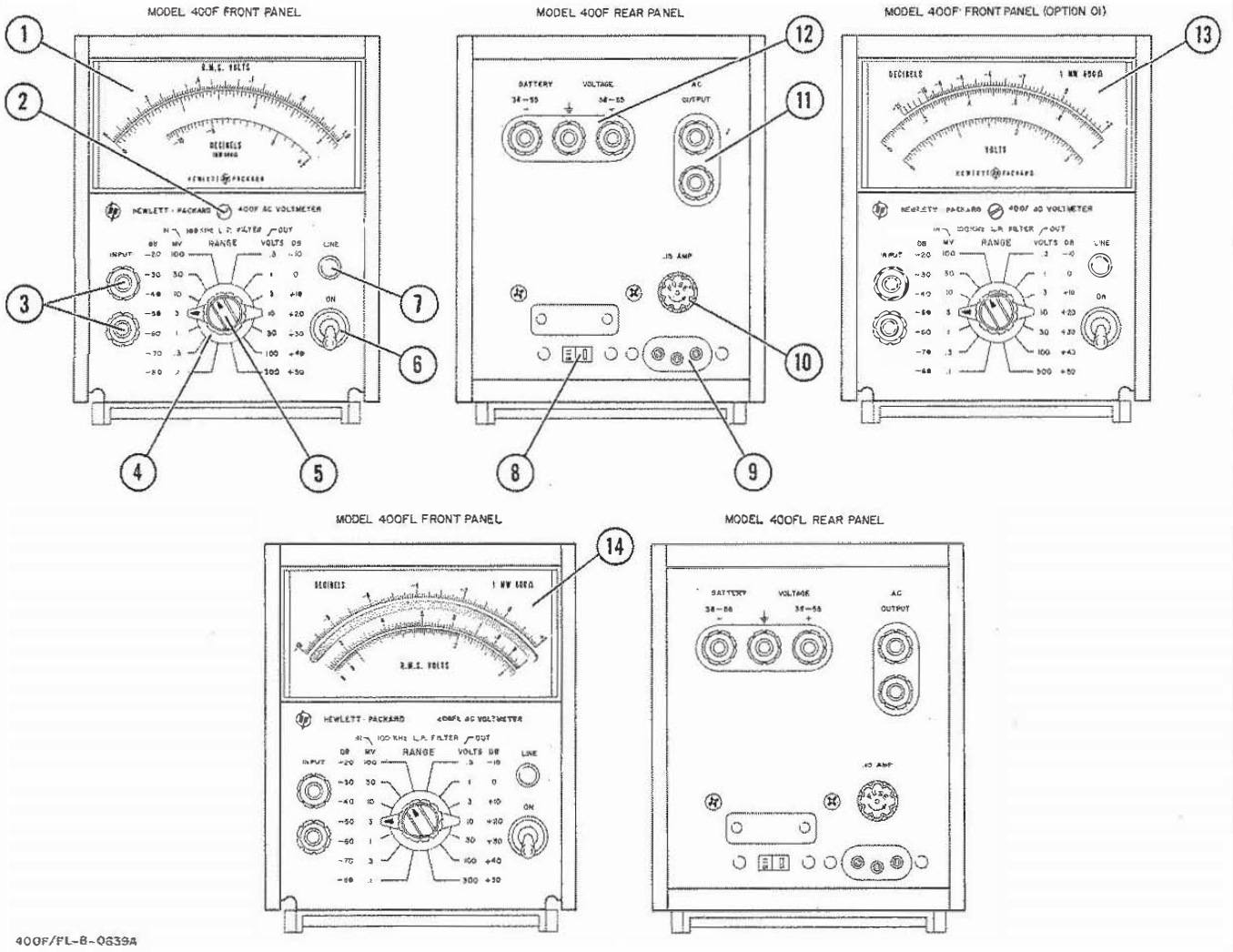
2-21. If original container is not to be used, proceed as follows:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material around all sides of instrument and protect panel face with cardboard strips.

c. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

d. Mark shipping container with "DELICATE INSTRUMENT", "FRAGILE" etc.



(1) 400F Scale: Indicates magnitude of applied signal in volts and dBm.

(2) Mechanical Zero Adjust: Provides a mechanical meter zero adjustment.

(3) INPUT Terminals: Connects signal to be measured to 400F/FL.

(4) RANGE Selector (S1): Selects full scale reading of meter. DBm reading on scale adds algebraically to dB setting of RANGE selector.

(6) 100 KHz LP FILTER Switch (S2): Switches 100 KHz filter either in or out of circuit.

(6) Line ON Toggle Switch (S3): Applies primary power.

(7) LINE Indicator Lamp: Indicates application of primary power.

(6) 115/230 Volt Slide Switch (S4): Selects 115 or 230 volts ac for line operation.

(9) Primary Power Connector: Line voltage is applied through this connector.

(10) FUSE: Protects instrument against current overload.

(11) AC OUTPUT: Ac amplifier output. Output impedance is 600 Ω.

(12) BATTERY VOLTAGE Terminals: 400F/FL may be powered by connecting two 35 to 55 volt batteries to these terminals.

(13) 400F Scale, Option 01: The dBm scale is placed uppermost for greater resolution.

(14) 400FL Scale: Indicates magnitude of applied signal in volts and dBm. DBm scale is linear, and voltage scales are logarithmic. This arrangement allows better resolution for dB reading. 0 dBm = 1mW in 600 Ω.

Figure 3-1. Location of Controls and Indicators

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section contains instructions and information necessary for the operation of the 400F/FL AC Voltmeters. Included is identification of controls, indicators and connectors, turn on procedures, and operating instructions.

3-3. CONTROLS, INDICATORS AND CONNECTORS.

3-4. Each control, indicator, and connector on the 400F/FL is identified and described in Figure 3-1.

3-5. METER MECHANICAL ZERO ADJUSTMENT (400F ONLY).

3-6. The mechanical zero adjustment is located in the center of the instrument front panel. If the meter pointer does not indicate zero after the instrument has been off at least one minute, mechanically zero the meter, following the steps outlined below.

a. Turn instrument power off, and allow at least one minute for meter pointer to stabilize.

b. Rotate zero adjustment screw clockwise until pointer is left of zero and moving upscale.

c. Continue rotating screw clockwise until pointer is at zero. Stop when pointer is exactly on zero. If pointer overshoots, repeat step b.

d. When pointer is exactly over zero, rotate adjustment screw slightly counterclockwise to relieve tension on pointer suspension. If pointer moves to the left, repeat whole procedure, but make counterclockwise rotation less.

3-7. TURN ON PROCEDURES.

a. If line voltage is used, ensure that the 115-230 vac switch (located on the rear panel) is in the correct position. Turn the line ON toggle switch to the ON position. The LINE lamp will glow, indicating that line power is applied.

b. If batteries are used, connect two 35 to 55 volt batteries as shown in Figure 3-2. The line ON switch is not in the circuit when batteries are used, therefore an external DPST switch should be used to provide a means for disconnecting the batteries when the instrument is not in use.

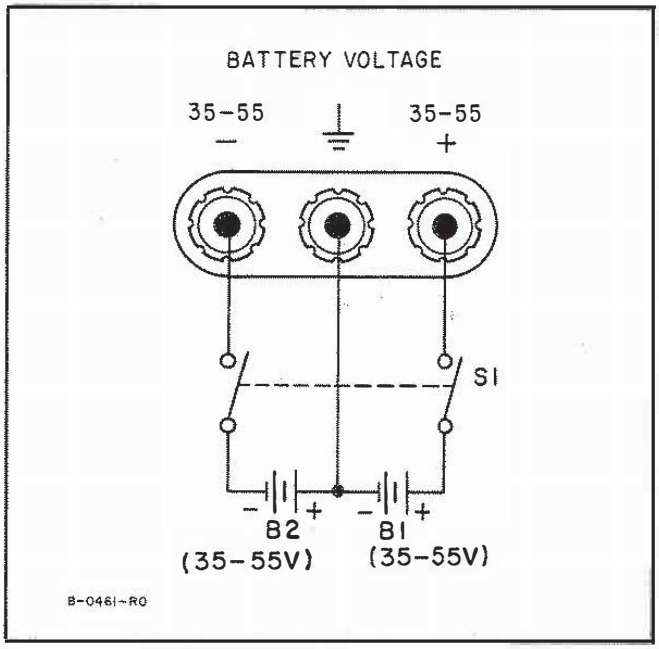


Figure 3-2. External Battery Connection

3-8. AC VOLTAGE MEASUREMENTS.

NOTE

Since the 400F/FL is average responding and rms calibrated, any distortion will affect the accuracy of the measurement. Table 3-1 shows the errors caused by distortions.

Table 3-1. Effect of Distortion on Average Responding Meter

HARMONIC	% DISTORTION	% ERROR (* Fundamental)	
		MAX. POSITIVE	MAX. NEGATIVE
Any even	0.1	0.000	
	0.5	0.001	
	1.0	0.005	
	2.0	0.020	
Third	0.1	0.033	0.033
	0.5	0.168	0.167
	1.0	0.338	0.328
	2.0	0.687	0.667
Fifth	0.1	0.020	0.020
	0.5	0.101	0.099
	1.0	0.205	0.195
	2.0	0.420	0.380

*Depends on phase relationship between harmonic and fundamental.

a. Perform the steps listed under Paragraphs 3-5 and 3-7.

b. Set the meter RANGE switch to the approximate range of the voltage to be measured.

CAUTION

DO NOT APPLY MORE THAN 600 VOLTS TO INPUT. DO NOT OVERLOAD THE .1 MV THROUGH .3 VOLT RANGES WITH MORE THAN 300 VOLTS AT FREQUENCIES BELOW 300 kHz OR WITH MORE THAN 64 VOLTS AT FREQUENCIES ABOVE 300 kHz. IF ANY OF THESE OVERLOADS ARE EXCEEDED, THE INSTRUMENT MAY BE DAMAGED.

c. If the signal to be measured is a frequency less than 100 kHz, the 100 kHz L. P. FILTER may be switched in to filter out all frequency components above 100 kHz.

d. Connect the signal to be measured to the INPUT terminals. The RMS voltage amplitude of the input will be indicated on the meter.

3-9. DB MEASUREMENTS.

a. Perform the steps listed under Paragraphs 3-5 and 3-7.

b. The dB measurement is equal to the algebraic sum of the meter indication and the RANGE setting. For example: if the RANGE setting is +20 dB, and the meter reading is -3 dB, the actual dB measurement is +17 dB.

c. The dB scale of the 400F/FL is calibrated in dBm. 0 dBm is equivalent to 1 milliwatt dissipated by a 600 ohm load. Therefore, all measurements in dBm must be made across a total impedance of 600 ohms. Measurements across all other impedances will be in dB, but not in dBm.

d. A reading in dB may be converted to dBm by using the Impedance Correction Graph (Figure 3-3). For example: to convert a 40 dB reading across 100 ohms to dBm, locate the 100 ohm load impedance on the bottom of the graph. Follow the impedance line to the heavy black line, and read the meter correction at that point. The correction for 100 ohms is +7.5 dBm, and the corrected reading is +47.5 dBm.

3-10. WIDE BAND AC AMPLIFIER.

CAUTION

EXTREME CARE SHOULD BE TAKEN TO AVOID COMMON GROUND PATHS BETWEEN THE INPUT AND OUTPUT SIGNALS. BECAUSE OF THE HIGH GAIN OF THE INSTRUMENT ON THE MORE SENSITIVE RANGES (80 DB ON .1 MV RANGE, ETC.), COMMON GROUND PATHS CAN CAUSE OSCILLATIONS AT HIGHER FREQUENCIES.

a. Perform the steps listed in Paragraphs 3-5 and 3-7.

b. Set the meter RANGE switch to the approximate range of the input signal.

c. When signals of frequencies less than 100 kHz are being amplified, the 100 kHz, L. P. FILTER may be switched in to reduce high frequency noise and lessen the possibility of oscillations.

d. Connect the input signal to the INPUT terminals.

e. Table 3-2 shows the gain factor for each range of the 400F/FL into an open circuit.

Table 3-2. AC Amplifier Gain Factors

RANGE	GAIN	RANGE	GAIN
300 V	-50 dB	100 mV	+20 dB
100 V	-40 dB	30 mV	+30 dB
30 V	-30 dB	10 mV	+40 dB
10 V	-20 dB	3 mV	+50 dB
3 V	-10 dB	1 mV	+60 dB
1 V	0 dB	.3 mV	+70 dB
.3 V	+10 dB	.1 mV	+80 dB

3-11. 400F WITH OPTION 01.

3-12. Operating procedures for the 400F with Option 01 are the same as the operating procedures for the standard 400F. The only difference between the two models is the scale layout. The 400F with Option 01 has a dB scale which reads from -15 to +2, instead of from -12 to +2. The dB scale is placed at the top of the meter face for better resolution.

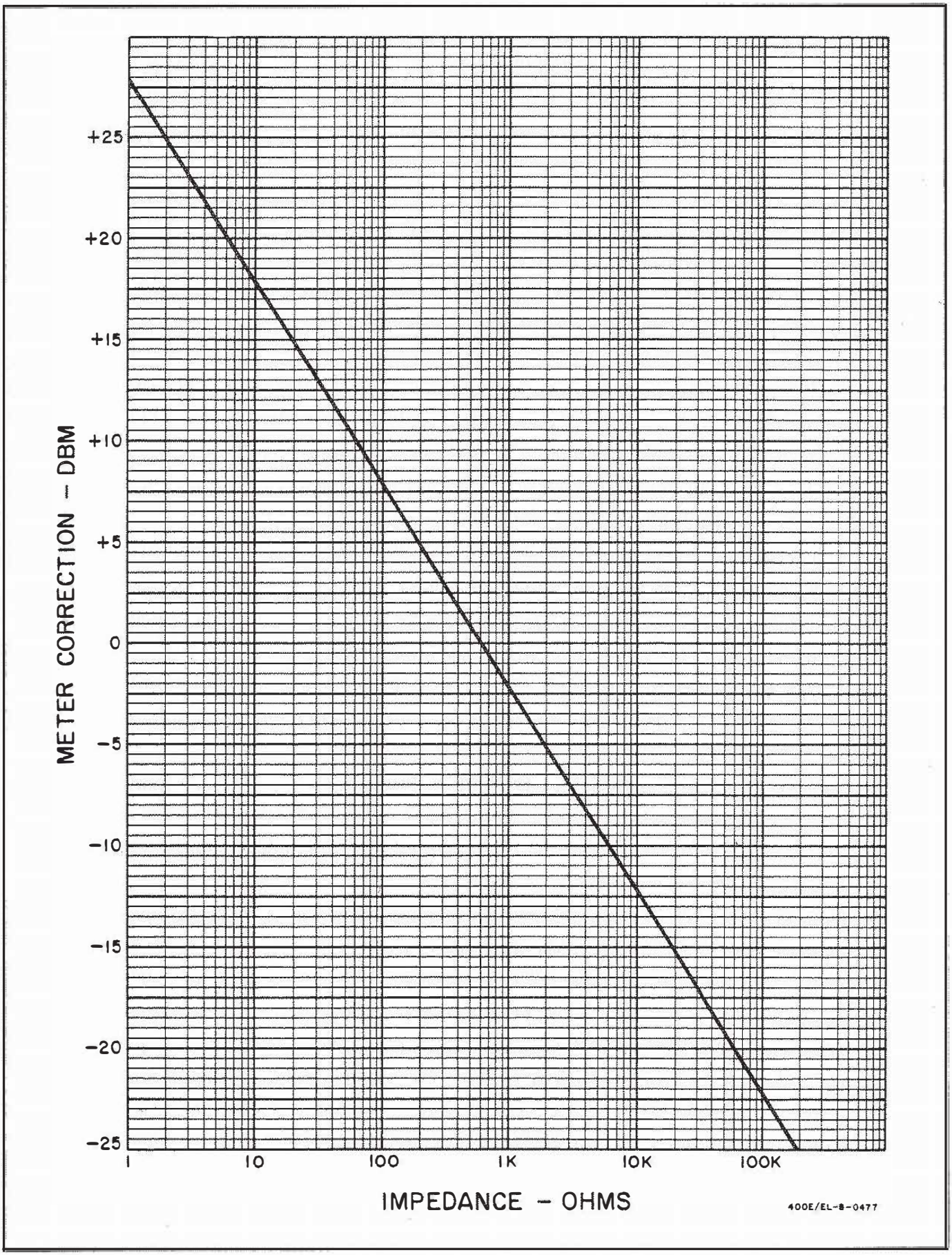


Figure 3-3. Impedance Correction Graph

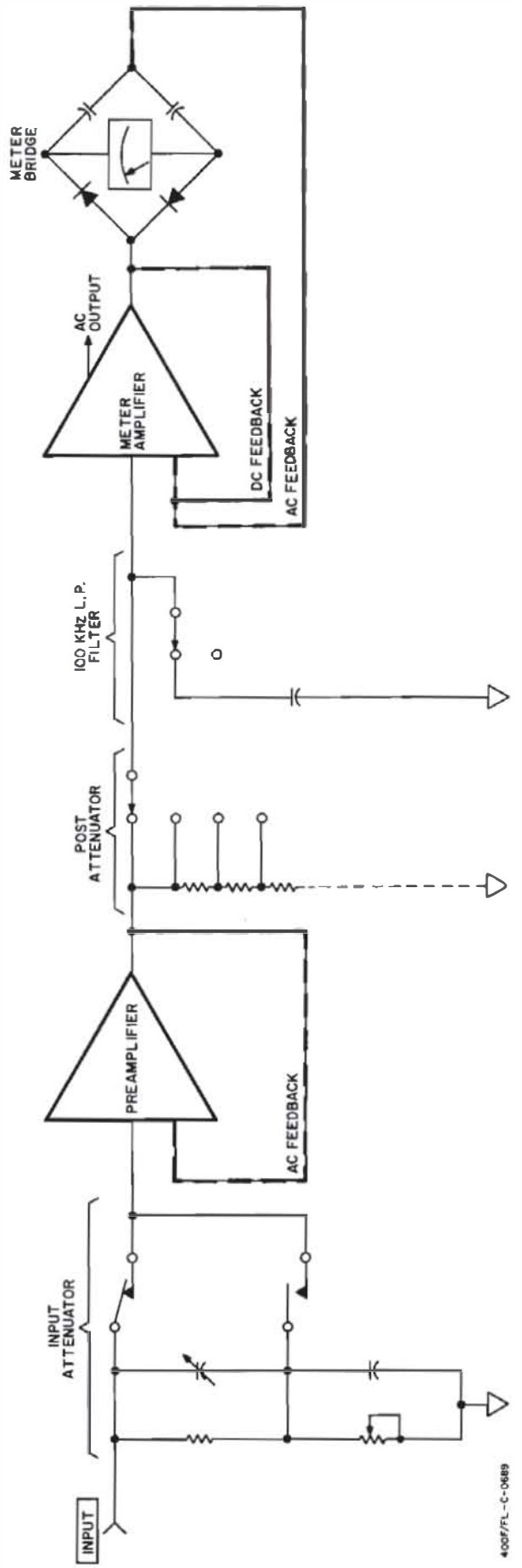


Figure 4-1. Functional Circuit Diagram

SECTION IV
THEORY OF OPERATION

4-1. GENERAL.

4-2. The 400F/FL is a solid state, average responding, rms calibrated ac voltmeter. It may also be used as a wide band ac amplifier, with switchable gain and switchable bandwidth. Refer to Figure 4-1 for a functional circuit diagram of the instrument.

4-3. BLOCK DIAGRAM DESCRIPTION.

4-4. The voltage to be measured is applied to the input attenuator, where it is either attenuated by 60 db, or coupled directly to the preamplifier. The preamplifier provides 10 db of gain for the input signal and applies it to the post attenuator. The signal goes from the post attenuator to the 100 KHz LOW PASS filter, which may be switched in to limit the bandwidth to signals from 20 Hz to 100 KHz. The meter amplifier then amplifies the signal, couples it to the meter bridge, and supplies a signal to the AC OUTPUT terminal. The meter bridge rectifies the ac signal and applies it to meter M1, which indicates the rms value of the input voltage. The meter bridge also provides the ac feedback to the meter amplifier.

4-5. SCHEMATIC THEORY.

4-6. Refer to Figure 6-1 for the following discussion.

4-7. INPUT ATTENUATOR.

4-8. The input attenuator consists of an rc voltage divider and two reed relays. On the .1 mv through .3 v ranges, reed relay A1K1 is energized by -26 v from wafer (A) of the RANGE switch, S1, routing the input signal directly to the preamplifier. On all other ranges, the -26 v is applied to relay A1K2. When A1K2 is closed, the input signal is attenuated 60 db by the rc divider and coupled to the preamplifier.

4-9. PREAMPLIFIER.

4-10. The preamplifier is a three stage ac amplifier that amplifies the signal from the input attenuator by 10 db. It also functions as an impedance matcher to match the high impedance of the input attenuator to the much lower impedance of the post attenuator.

4-11. Capacitor A2C5 blocks dc transients and couples the ac signal to the preamplifier. The input signal is limited to 5.4 volts peak-to-peak by diodes A2CR2 and A2CR4, which are biased at +2.7 v and -2.7 v respectively, by zener diodes A2CR1 and A2CR5. A field effect transistor, A2Q1, is used as the input stage of the preamplifier because of its low noise characteristics and high input impedance. The signal is taken from the drain of A2Q1 and is further amplified by A2Q2 and A2Q3.

4-12. Feedback from the emitter of A2Q2 bootstraps the value of A2R9, the drain load of A2Q1. Feedback from the source of A2Q1 bootstraps the input impedance of the preamplifier and keeps it at a high level over all ranges of inputs. Gain stability and linearity of the preamplifier are maintained by feedback from the collector of A2Q2 and the emitter of A2Q3. A2R6 provides a bias adjustment for the fieldeffect transistor, A2Q1.

4-13. POST ATTENUATOR.

4-14. The post attenuator is a precision resistive voltage divider that operates as a function of the RANGE switch. On the two lowest voltage ranges, the signal from the preamplifier is applied through two resistors (S1R1 and S1R15) to the 100 KHz LP FILTER and receives no attenuation. Six precision resistive divider circuits provide signal attenuation in progressive steps of 10 db for the twelve higher ranges.

4-15. 100 KHz LOW PASS FILTER.

4-16. The 100 KHz LP FILTER is a 0.01 μf capacitor (S2C1) which may be switched into or out of the circuit by switch S2. When the filter is in the circuit, the bandwidth of the instrument is from 20 Hz to 100 KHz. If the filter is switched out of the circuit, the bandwidth is increased to 4 MHz. Refer to Figure 4-2 for a graph of the filter attenuation characteristics.

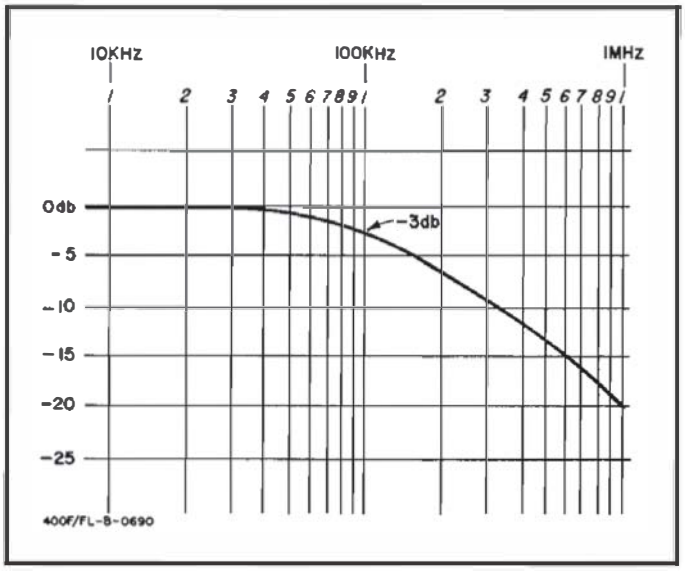


Figure 4-2. Filter Attenuation Characteristics

4-17. METER AMPLIFIER.

4-18. The meter amplifier is a four stage, direct coupled voltage and power amplifier. The first stage is a differential amplifier, A2Q10 and A2Q12, which amplifies the difference between the input signal and the feedback signal on the base of A2Q12, the feedback summing junction. The three other stages of amplification are provided by A2Q11, A2Q13, and A2Q15.

4-19. AC feedback from the meter bridge to the feedback summing junction is adjustable at 4 MHz (A2C36) and 400 Hz (A2R62) on the 30 mv range. On the .1 mv range, A2R64, A2R76, and A2R68 are switched into the circuit to increase the gain of the amplifier by 10 db and to allow a 400 Hz gain adjustment to be made.

4-20. DC feedback from the collector of A2Q15 to the feedback summing junction is adjustable at 20 Hz (A2R59) on the 30 mv range. A2R58 is switched into the circuit on the .1 mv range to provide a feedback adjustment at 30 Hz. These adjustments provide overall amplifier gain stability for the entire voltage and frequency range of the instrument.

4-21. A2Q14 isolates the AC OUTPUT circuit from the meter amplifier and the meter bridge. It is an independent current source which will supply a signal to the OUTPUT terminal that is identical to the signal applied to the meter bridge. That is, for a 1 v rms signal for full scale meter deflection, A2Q14 will provide a 1 v rms signal at the AC OUTPUT terminal.

4-22. METER BRIDGE.

4-23. Refer to Figure 4-3 for a simplified diagram of the metering circuit.

4-24. The meter bridge is a full wave rectifier that converts the ac signal from the meter amplifier into dc. It supplies current to drive the meter and provides an ac feedback signal to the meter amplifier.

4-25. Transistor A2Q16 provides a large output impedance for the meter amplifier, and is the current drive source for the meter bridge circuit. The collector output of A2Q16 is applied to the meter bridge, and is rectified by diodes A2CR22 and A2CR23. The ac components of the bridge signal are coupled into the feedback loop by capacitors A2C38 and A2C39. A2Q17 bootstraps the resistance of A2R69 to a high value, so that current is driven through the bridge, keeping the meter circuit response linear to large variations in signal amplitude.

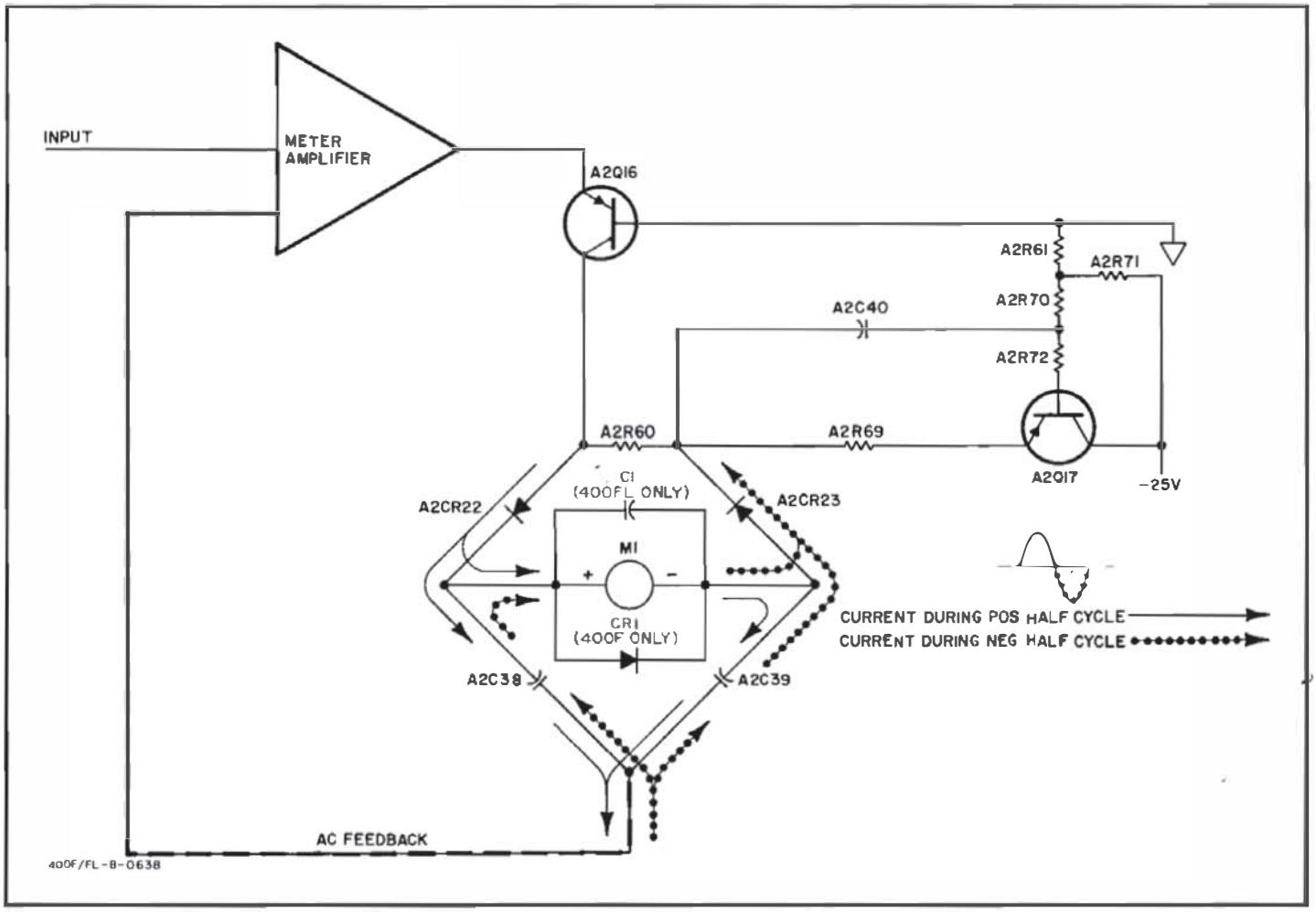


Figure 4-3. Simplified Diagram of Metering Circuit

4-26. The meter, M1, is a current driven device that utilizes a taut-band movement. It responds to the average value of the rectified meter amplifier output, which is proportional to the rms value of the sinusoidal signal being measured. The meter indicates the rms value of the input voltage and the power level in dbm for resistive loads of 600 ohms. Measurements across loads other than 600 ohms will be indicated in db, but not dbm. The meter is protected from circuit overloads by diode CR1 (400F) and capacitor C1 (400FL).

4-27. POWER SUPPLY.

4-28. The power supply provides both a positive and negative 26 v regulated output. It may be operated by external batteries (+35 v to 55 v and -35 v to 55 v) or line power (115 v or 230 v, 50 Hz to 1000 Hz).

4-29. The line input is converted to dc by a diode rectifier network consisting of A2CR6 through A2CR9. The positive output of the rectifier is applied to series regulator A2Q4, which regulates the +26 v supply. Control transistor A2Q6 has a constant emitter reference voltage supplied by zener diode A2CR12. Capacitor A2C16 couples any change in the +26 v output to the base of A2Q6, which will supply a signal proportional to the change in output voltage to A2Q5. A2Q5 will then amplify the signal and couple it to the base of the regulator A2Q4, causing it to regulate the output by either increasing or decreasing conduction.

4-30. The -26 v supply is regulated in the same manner, the only difference being that the control transistor A2Q7 is referenced to the +26 v output, instead of the zener diode.

Table 5-1. Test Equipment

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
AC Voltmeter Calibrator	Accuracy: 0.2% at 400 Hz Range: 30 mv to 1 v	Performance Checks and Calibration	-hp- Model 738BR Voltmeter Calibrator
Test Oscillator	Output: 30 mv to 1 v Frequency Range: 20 Hz to 4 MHz Distortion: <1% Flatness: ±0.25%	Performance Checks and Calibration	-hp- Model 652A Test Oscillator or Combination -hp- Model 739AR Frequency Response Test Set and -hp- Model 200SR Oscillator
AC/DC Voltmeter/Ohmmeter	Volts Accuracy: 2% Ohms Accuracy: 5%	Troubleshooting	-hp- Model 427A Voltmeter
Resistor	Fxd, 100 K Ω ±1%	Performance Checks	-hp- Part No. 0757-0465
Crystal Socket (with terminals shorted)	Size: 1/2 inch	Performance Checks and Calibration (Shorting Test Points)	-hp- Part No. 1200-0028

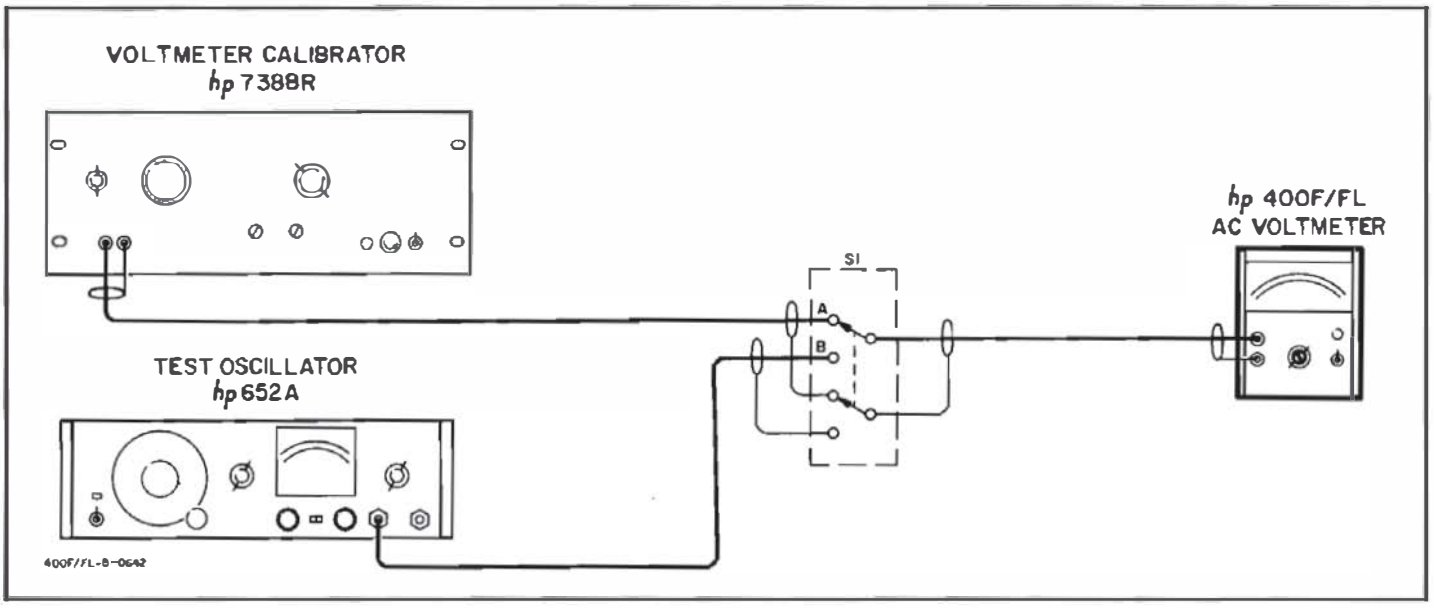


Figure 5-1. Accuracy and Frequency Response Check Setup

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains maintenance and service information for the Model 400F/FL AC Voltmeter. Included are Performance Checks, Alignment and Calibration Procedures, and Troubleshooting Procedures.

5-3. TEST EQUIPMENT REQUIRED.

5-4. The equipment required to properly maintain the 400F/FL is listed in Table 5-1. The table lists the type of equipment to be used, the specification requirements, and the recommended commercially available test equipment.

NOTE (400F only)

Before beginning the Performance Tests, mechanically zero the meter according to the procedures in Paragraph 3-7.

5-5. PERFORMANCE CHECKS.

5-6. The following Performance Checks compare the 400F/FL with its accuracy specifications (Table 1-1). These checks may be used for incoming inspection, periodic maintenance, and for specification checks after a repair. A highly accurate and stable voltage reference that is variable from 20 Hz to 4 MHz is required. The -hp- 738BR Voltmeter Calibrator produces a 400 Hz signal that is within less than 0.2% of the indicated output. The -hp- 652A Test Oscillator can be referenced to the output of the 738BR and can be adjusted to within 0.25% of the set reference voltage from 20 Hz to 4 MHz.

5-7. If the -hp- 652A Test Oscillator is not available, the 739AR Frequency Response Test Set and 200SR Oscillator combination may be used. This combination can be adjusted to within 0.5% of a set voltage reference from 20 Hz to 4 MHz. (The -hp- 739AR, -hp- 200SR, and -hp- 738BR are available in a rack mounted configuration designated -hp- K02-738BR VTVM Calibration System.)

5-8. The following procedures specify the use of the -hp- 652A and the -hp- 738BR. If the K02-738BR calibration system is used, follow the same general procedures.

5-9. Figure 5-1 shows the test setup for using the -hp- 652A and -hp- 738BR combination. Figure 5-2 shows the test setup for using the K02-738BR VTVM Calibration System.

NOTE

The 0.1 mv range of the 400F/FL may be checked for accuracy by verification of the additional 10 db of gain that is provided by the meter amplifier on that range. In order to verify the gain, the top cover of the instrument must be removed to gain access to TP1 through TP4.

5-10. TOP COVER REMOVAL.

5-11. To remove or replace the top cover, follow the procedures outlined in Paragraph 5-21.

5-12. ACCURACY AND FREQUENCY RESPONSE CHECKS.

5-13. The accuracy and frequency response checks compare the 400F/FL with its accuracy specifications over the entire frequency range.

a. Connect the voltmeter calibrator and the Test Oscillator to the 400F/FL as shown in Figure 5-1. An external switch (S1) may be used to facilitate switching from one test instrument to the other.

b. Set 400F/FL RANGE switch to 30 mv, and set 100 KHz FILTER switch to OUT. Set switch S1 to Position A.

c. Adjust voltmeter calibrator for a 30 mv rms output at 400 Hz.

d. Observe the 400F/FL meter indication. If the meter indication is not within the tolerances listed in Table 5-2 (400F) or Table 5-3 (400FL), perform the Meter Calibration (Paragraph 5-28).

e. Set 400F/FL RANGE switch to 100 mv. The meter should indicate 30 mv.

f. Short TP1 to TP4, and short TP2 to TP3. (A shorting device, such as a crystal socket with its terminals shorted together, should be used to avoid pickup of noise.) The meter indication should be the same as the indication in step d of this paragraph (±3 mv). This verifies the additional 10 db of gain that is provided by the meter amplifier on the 0.1 mv range.

g. Set 400F/FL RANGE switch to 1 volt, and disconnect shorts between test points.

h. Adjust voltmeter calibrator for a 1 volt output at 400 Hz. Observe the 400F/FL meter indication. If the meter indication is not within the tolerances listed in Table 5-2 (400F) or Table 5-3 (400FL), perform the Meter Calibration (Paragraph 5-28).

i. Set switch S1 to Position B, and set 400F/FL RANGE switch to 30 mv.

Table 5-2. Full Scale Calibration Tolerances (400F)

30 MV RANGE			100 MV RANGE (0.1 mv Range Check)			1 VOLT RANGE		
FREQ.	METER INDICATION		FREQ.	METER INDICATION		FREQ.	METER INDICATION	
	MIN.	MAX.		MIN.	MAX.		MIN.	MAX.
20	28.8	31.2	20	96	104	20	0.96	1.04
40	29.4	30.6	40	98	102	40	0.98	1.02
400	29.7	30.3	400	99	101	400	0.99	1.01
1000	29.7	30.3	1000	99	101	1000	0.99	1.01
10 K	29.7	30.3	10 K	99	101	10 K	0.99	1.01
100 K	29.7	30.3	100 K	99	101	100 K	0.99	1.01
1 M	29.7	30.3	1 M	99	101	1 M	0.99	1.01
2 M	29.4	30.6	2 M	98	102	2 M	0.98	1.02
4 M	28.8	31.2	4 M	96	104	4 M	0.96	1.04

Table 5-3. Full Scale Calibration Tolerances (400FL)

30 MV RANGE			100 MV RANGE (0.1 mv Range Check)			1 VOLT RANGE		
FREQ.	METER INDICATION		FREQ.	METER INDICATION		FREQ.	METER INDICATION	
	MIN.	MAX.		MIN.	MAX.		MIN.	MAX.
20	28.5	31.5	20	95	105	20	0.95	1.05
40	29.4	30.6	40	98	102	40	0.98	1.02
400	29.7	30.3	400	99	101	400	0.99	1.01
1000	29.7	30.3	1000	99	101	1000	0.99	1.01
10 K	29.7	30.3	10 K	99	101	10 K	0.99	1.01
100 K	29.7	30.3	100 K	99	101	100 K	0.99	1.01
1 M	29.7	30.3	1 M	99	101	1 M	0.99	1.01
2 M	29.4	30.6	2 M	98	102	2 M	0.98	1.02
4 M	28.5	31.5	4 M	95	105	4 M	0.95	1.05

j. Adjust test oscillator set for a 30 mv output at 400 Hz, using as a reference the 400F/FL meter indication obtained in step d of this paragraph. Set a reference on meter of test oscillator and use amplitude control to maintain the set reference whenever frequency of oscillator is varied.

k. Repeat step d of this paragraph for each frequency listed in Table 5-2 (400F) or Table 5-3 (400FL).

m. Perform steps e and f of this paragraph, maintaining the output amplitude of the test oscillator at 30 mv.

n. Repeat step d of this paragraph for each frequency listed in Table 5-2 (400F) or Table 5-3 (400FL).

o. Set 400F/FL RANGE switch to 1 volt, and disconnect shorts between test points.

p. Adjust test oscillator for a 1 volt output at 400 Hz using as a reference the 400F/FL meter indication obtained in step h of this paragraph.

q. Repeat step d of this paragraph for each frequency listed in Table 5-2 or Table 5-3.

5-14. RANGE TRACKING CHECK.

5-15. After verifying the 400F/FL full scale calibration with the accuracy and frequency response tests, check the range tracking of the instrument with the following procedures. Use the test setup shown in Figure 5-1 for the range tracking check.

a. Set switch S1 to Position A.

b. Set 400F/FL RANGE switch to 30 mv.

c. Adjust test oscillator for a 400F/FL meter indication of 30 mv at 400 Hz.

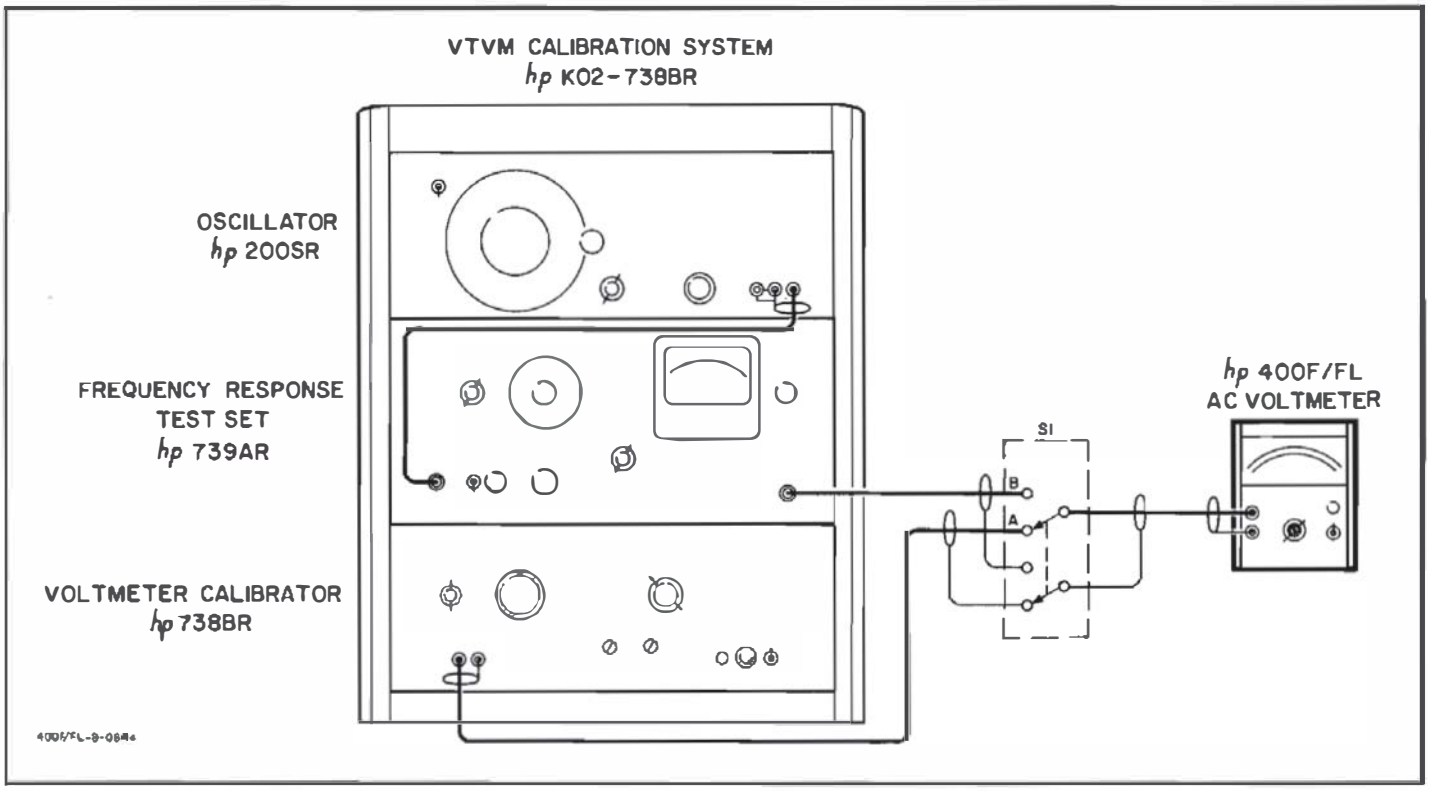


Figure 5-2. Alternate Accuracy and Frequency Response Check Setup

d. Set 400F/FL RANGE switch to 100 mv.
   1) 400F should indicate 30 mv ±2%.
   2) 400FL should indicate 30 mv ±1%.

e. Set 400F/FL RANGE switch to 0. 3 volts.
   1) 400F should indicate 30 mv ±5%.
   2) 400FL cannot be checked with a 1/10 scale input.

f. Adjust test oscillator for a 400F/FL meter indication of 30 mv at 1 MHz.

g. Set 400F/FL RANGE switch to 100 mv.
   1) 400F should indicate 30 mv ±2%.
   2) 400FL should indicate 30 mv ±1%.

h. Set 400F/FL RANGE switch to 0. 3 volts.
   1) 400F should indicate 30 mv ±5%.
   2) 400F/FL cannot be checked with a 1/10 scale input.

5-16. INPUT IMPEDANCE CHECK.

5-17. INPUT RESISTANCE CHECK.

a. Connect the 50 Ω output of the test oscillator to 400F/FL.

b. Set 400F/FL RANGE switch to 1 volt.

c. Set test oscillator output for full scale deflection of 400F/FL.

d. Connect a 100 K Ω resistor between test oscillator and 400F/FL as shown in Figure 5-3.

e. 400F/FL meter indication should not drop more than one small scale division from full scale. This verifies an input resistance of 10 M Ω.

5-18. INPUT CAPACITY CHECK.

a. Connect test oscillator and a 100 K Ω resistor to 400F/FL as shown in Figure 5-3. Connect the resistor lead directly to the GR connector.

b. Set 400F/FL RANGE switch to 1 volt.

c. Set test oscillator output for full scale deflection of 400F/FL meter at 400 Hz.

d. Increase frequency of test oscillator until 400F/FL indication drops to 0. 707 volts. This should occur at a frequency of 150 KHz or greater, verifying an input capacity of 10 pf or less on the 1 volt range.

e. Set 400F/FL RANGE switch to 300 mv.

f. Set frequency response test set output for full scale deflection of 400F/FL meter at 400 Hz.

g. Increase frequency of test oscillator until 400F/FL indication drops to 212 mv. This should occur at a frequency of 60 KHz or greater, verifying an input capacity of 25 pf or less on the 300 mv range.

5-19. ALIGNMENT AND CALIBRATION PROCEDURES.

5-20. The Alignment and Calibration Procedures should be performed only if it has been determined by the Performance Checks that the 400F/FL is not within

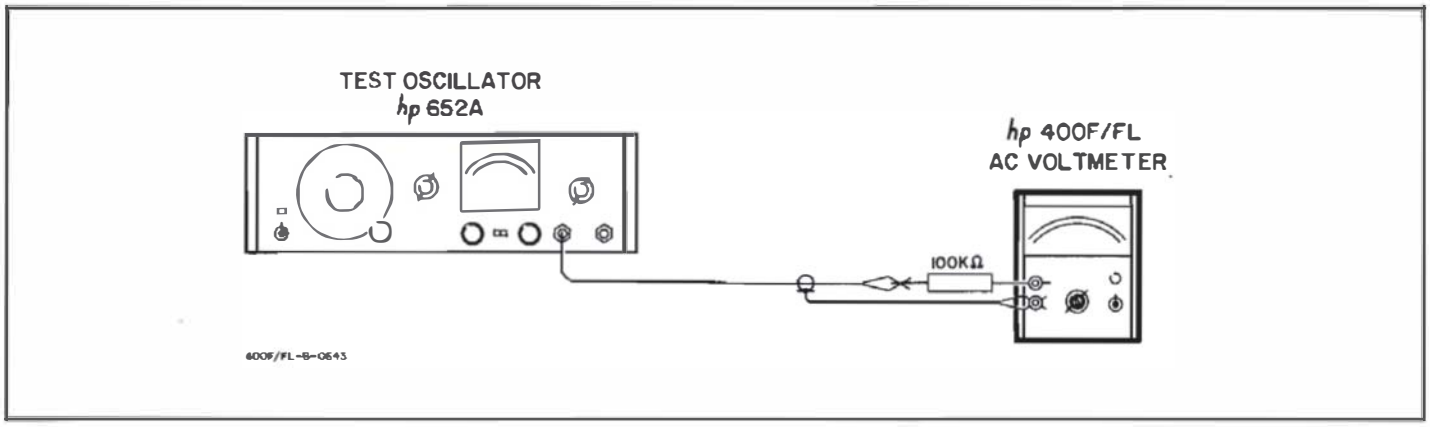


Figure 5-3. Input Impedance Check Setup

specifications. The following procedures specify the use of an -hp- 738BR Voltmeter Calibrator and an -hp- 652A Test Oscillator. However, an -hp- K02-738BR VTVM Calibration System may be substituted by following the same general procedures. If the instrument cannot be properly adjusted, refer to Paragraph 5-39, Troubleshooting Procedures. Refer to Figure 5-4 for the location of internal adjustments.

5-21. COVER REMOVAL AND REPLACEMENT.

5-22. Removal of the top cover exposes circuit areas for routine checks and adjustments. Removal of the bottom and side covers exposes circuit areas for operations such as soldering and component replacement.

5-23. TOP OR BOTTOM COVERS.

a. Remove screw at rear of cover. Slide cover about 1 inch to rear, and lift it off.

b. To replace cover, reverse the removal procedure.

5-24. SIDE COVER.

5-25. Remove the four screws from side cover, and lift it off.

5-26. METER MECHANICAL ZERO ADJUSTMENT.

5-27. Refer to Paragraph 3-5 for the meter mechanical zero adjustment procedures.

5-28. METER CALIBRATION.

5-29. The following procedures are used to adjust the gain of the meter amplifier on two voltage ranges at five different frequencies. Proper gain adjustments will assure accurate meter indications over the entire voltage and frequency range of the instrument. Use the test setup shown in Figure 5-1 for the meter calibration.

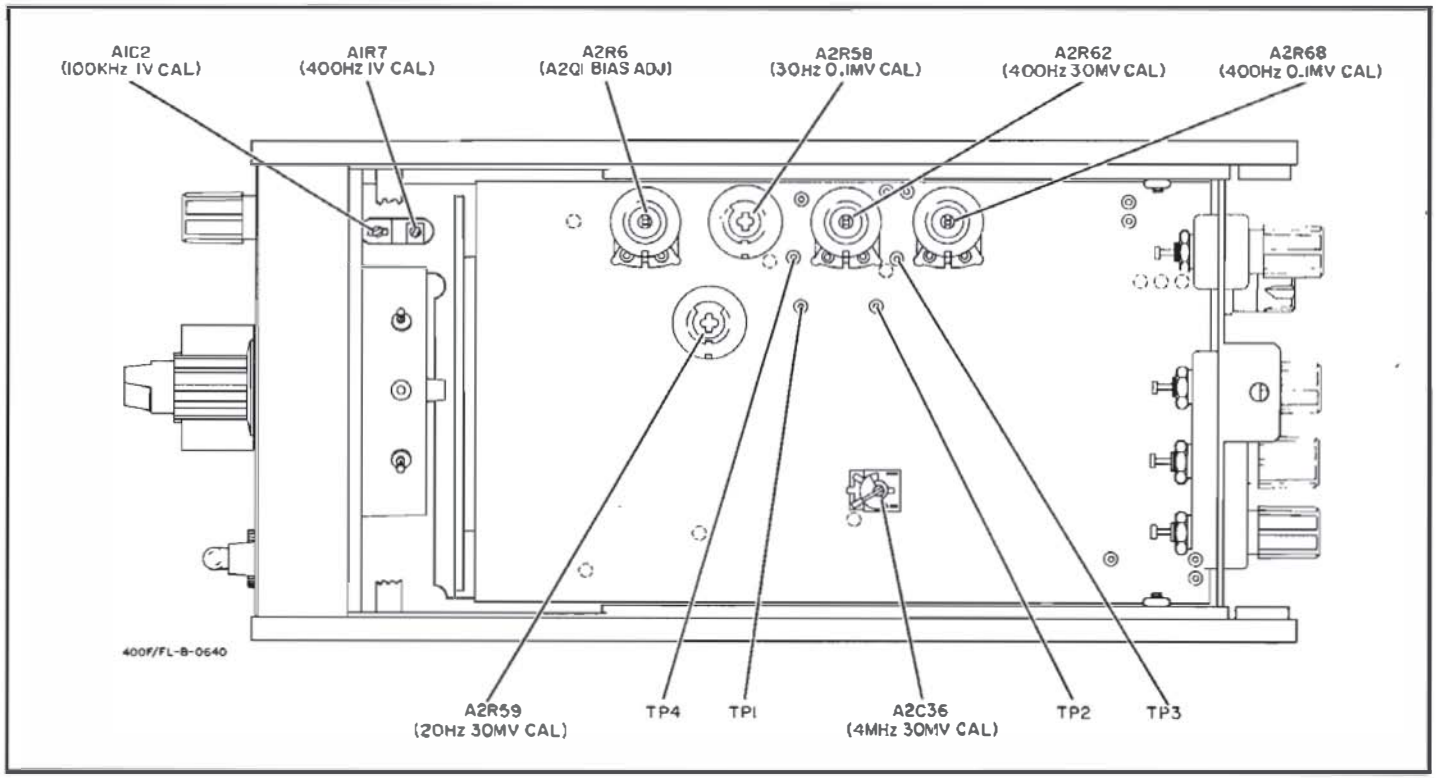


Figure 5-4. Location of Internal Adjustments

5-30. METER CALIBRATION, 30 MV RANGE.

a. Set switch S1 to Position A.

b. Set 400F/FL RANGE switch to 30 mv, and set 100 KHz L. P. FILTER switch to OUT.

c. Set voltmeter calibrator for 30 mv output at 400 Hz.

d. Adjust A2R62 for a 400F/FL meter indication of 30 mv.

e. Set switch S1 to Position B.

f. Adjust test oscillator for a 400F/FL meter indication of 30 mv at 400 Hz. Set a reference on meter of test oscillator and use amplitude control to maintain reference whenever frequency of oscillator is changed.

g. Set test oscillator to 20 Hz, maintaining amplitude at 30 mv.

h. Adjust A2R59 for a 400F/FL meter indication of 30mv.

i. Set test oscillator to 4 MHz, maintaining amplitude at 30 mv.

j. Adjust A2C36 for a 400F/FL meter indication of 30 mv.

5-31. METER CALIBRATION, 0.1 MV RANGE.

NOTE

The 0.1 mv range meter calibration is performed on a higher range. This is done by shorting test points which provide the amplifier with the additional 10 db of gain that normally is switched in only on the 0.1 mv range.

a. Set switch S1 to Position B.

b. Set 400F/FL RANGE switch to 30 mv, and set 100 KHz L. P. FILTER switch to OUT.

c. Adjust test oscillator for a 400F/FL meter indication of 30 mv at 400 Hz.

d. Set 400F/FL RANGE switch to 100 mv.

e. Short TP1 to TP4 and short TP2 to TP3. (This increases the gain of the meter amplifier by 10 db, as if the instrument were on the 0.1 mv range.)

f. Adjust A2R68 for a 400F/FL meter indication of 30 mv. (Although the 400F/FL RANGE switch is in the 100 mv position, the instrument effectively is still on the 30 mv range.)

g. Set test oscillator to 30 Hz, maintaining amplitude at 30 mv.

h. Adjust A2R58 for a 400F/FL meter indication of 30 mv.

5-32. ATTENUATOR ALIGNMENT.

5-33. The following procedures are used to properly align the input attenuator of the 400F/FL at both high and low frequencies. Use the test setup shown in Figure 5-1 for the attenuator alignment.

a. Set switch S1 to Position A.

b. Set 400F/FL RANGE switch to 1 volt, and set 100 KHz L. P. FILTER switch to OUT.

c. Adjust voltmeter calibrator for a 1 volt output at 400 Hz.

d. Adjust A1R7 for a 400F/FL meter indication of 1 volt.

e. Set switch S1 to position B.

f. Set test oscillator for a 400F/FL meter indication of 1 volt at 400 Hz.

g. Set test oscillator to 100 KHz, maintaining the amplitude at 1 volt.

h. Adjust A1C2 for a 400F/FL meter indication of 1 volt. If more than a 1% adjustment is needed, repeat the 400 Hz adjustment.

5-34. A2Q1 BIAS ADJUSTMENT.

5-35. A2R6 provides a bias adjustment for field effect transistor A2Q1.

a. Monitor voltage at junction between A2R5 and A2R3 with a dc voltmeter.

b. Adjust A2R6 for a -6 v indication at the junction.

5-36. REPLACEMENT OF A2C37*.

5-37. The value of A2C37 is individually selected to compensate for varying circuit parameters within the instrument. Certain Model 400F/FL instruments may not have a capacitor in this location.

5-38. If an instrument cannot be properly calibrated on the 30 mv range at 4 MHz, A2C37 should be changed. Increase the value of A2C37 if the instrument meter indication is high and cannot be adjusted low enough. Decrease the value of A2C37 if the instrument meter indication is low and cannot be adjusted high enough.

5-39. TROUBLESHOOTING PROCEDURE.

5-40. If the 400F/FL is operating improperly, it either needs to be calibrated or has a circuit that is malfunctioning. Troubleshoot the instrument only after it has been determined that the malfunction cannot be corrected by performing the Alignment and Calibration Procedures in Paragraph 5-19.

5-41. When a malfunction occurs, remove power from the 400F/FL and visually inspect for loose or broken wires and connectors. Also check for overheated or loose components and similar conditions that could be a source of trouble.

5-42. The checks outlined in this section were not designed to measure all circuit parameters, but to localize the malfunction. Therefore, it is probable that additional checks and measurements will be required to completely isolate the faulty component.

Table 5-4. Troubleshooting Guide

MALFUNCTION INDICATION	PROBABLE TROUBLE
Instrument will not operate on line voltage, and LINE ON lamp will not light.	Fuse F1 open.
Instrument will not uprange above 0.3 volt, but works on 0.3 volt range and below.	Relay A2K1 stuck closed, or A2K2 stuck open.
Instrument will not downrange below 1 volt, but works on 1 volt range and above.	Relay A2K1 stuck open, or A2K2 stuck closed.
Voltage at A2R8 cannot be properly adjusted.	Impedance Converter Circuit (A2Q1, A2Q2 and A2Q3).
No voltage at A2L1.	Jumper wire #1 broken.
Power supply output unregulated.	A2Q6, A2Q7 or Zener diode A2CR12.
No ac output.	A2R33 shorted.
Instrument operates improperly with inputs above 100 KHz, but works with inputs of lower frequencies.	Filter switch S2.
Instrument will not operate properly on 0.1 mv range.	Range switch S1, wafer D.
Meter deflection on all ranges with no input.	A2Q15, A2Q16, A2Q17. A2C38, A2C39, A2C40.
Meter remains at zero with any input on any range.	Diode A2CR1 shorted (400F only), or capacitor A2C1 shorted (400FL only).

5-43. Refer to Table 5-4 for a list of possible malfunctions and their probable causes.

NOTE

All the voltage measurements in this section should be made with the 400F/FL input shorted and the RANGE switch set to 1 volt.

5-44. POWER SUPPLY.

5-45. Measure the power supply outputs at jumper wires #1 and #2 for +26 v and -26 v respectively. If both outputs are incorrect, first check the components in the +26 v section of the power supply, because the control transistor in the -26 v supply is referenced to the +26 v output. Consequently, if the +26 v becomes unregulated, the -26 v will also be unregulated. Refer to Table 5-5 for a list of check point voltages in the power supply.

Table 5-5. Power Supply Voltages

CHECK POINT	VOLTAGE
Emitter Q4	+26.0 v ±1 v
Collector Q4	+41.5 v ±5 v
Collector Q6	+27.5 v ±1 v
Emitter Q8	-26.0 v ±1 v
Emitter Q9	-43.5 v ±5 v

5-46. AMPLIFIERS.

5-47. Both the preamplifier and the meter amplifier are internally dc coupled. If the dc voltages anywhere in the amplifiers are incorrect, the amplifiers will not operate properly. Measure the dc voltages in the amplifiers at the check points listed in Tables 5-6 and 5-7.

Table 5-6. Preamplifier Voltages

CHECK POINT	VOLTAGE
Source Q1	- 2.3 v ±0.5 v
Drain Q1	-17.0 v ±2.0 v
Collector Q2	- 7.5 v ±0.5 v
Collector Q3	-21.4 v ±1.0 v

Table 5-7. Meter Amplifier Voltages

CHECK POINT	VOLTAGE
Emitter Q10	- 0.64 v ±0.1 v
Collector Q10	+ 9.20 v ±1.0 v
Collector Q11	+ 0.97 v ±0.2 v
Collector Q12	+22.00 v ±1.0 v
Collector Q13	+11.00 v ±0.5 v
Collector Q15	+ 2.30 v ±0.5 v

5-48. METER BRIDGE.

5-49. Measure the dc voltages on the transistors in the meter bridge and compare the readings with those given in Table 5-8. Also measure the voltages at the meter terminals. The meter should be floating at approximately -9 volts ±1 volt with respect to circuit ground.

Table 5-8. Meter Bridge Voltages

CHECK POINT	VOLTAGE
Collector Q16	- 9 v ±1 v
Base Q17	-17 v ±1 v

5-50. ETCHED CIRCUIT BOARD REPAIR.

5-51. The Model 400F/FL uses plated-through, double-sided, etched circuit boards. To prevent damage to

the circuit board and components, observe the following rules when soldering:

a. Use a low-heat (25 to 50 watts) soldering iron with a small tip (1/16" to 3/32" diameter).

b. To remove a component, clip a heat sink (long nose pliers, commercial heat sink tweezers etc.) on the component lead as close to the component as possible. Place the soldering iron directly on the component lead, and pull up on the lead. If a component is obviously damaged or faulty, clip the leads close to the component and then remove the leads from the board.

CAUTION

EXCESSIVE OR PROLONGED HEAT CAN LIFT THE CIRCUIT FOIL FROM THE BOARD OR CAUSE DAMAGE TO COMPONENTS.

c. Clean the component lead holes by heating the solder in the hole, quickly removing the soldering iron, and inserting a pointed, non-metallic object such as a toothpick.

d. To mount a new component, shape the leads and insert them in the holes. Clip a heat sink on the component, heat with the soldering iron, and add solder as necessary to obtain a good electrical connection.

e. Clip excess leads off after soldering and clean excess flux from the connection and adjoining area, using type TF Freon (-hp- Part No. 8500-0232).

SECTION VI
SCHEMATICS

6-1. INTRODUCTION.

6-2. This section contains the schematic and component location diagrams for the Model 400F/FL. Figure 6-1 shows a flattened view of the RANGE switch and part of the internal wiring data. Figure 6-2 shows the component location on the A1 and A2 printed circuit boards, and the location of the internal adjustments. Figure 6-3 is the schematic diagram of the 400F/FL. Main signal paths and feedback paths are identified. (Refer to the notes on the schematic diagram.)

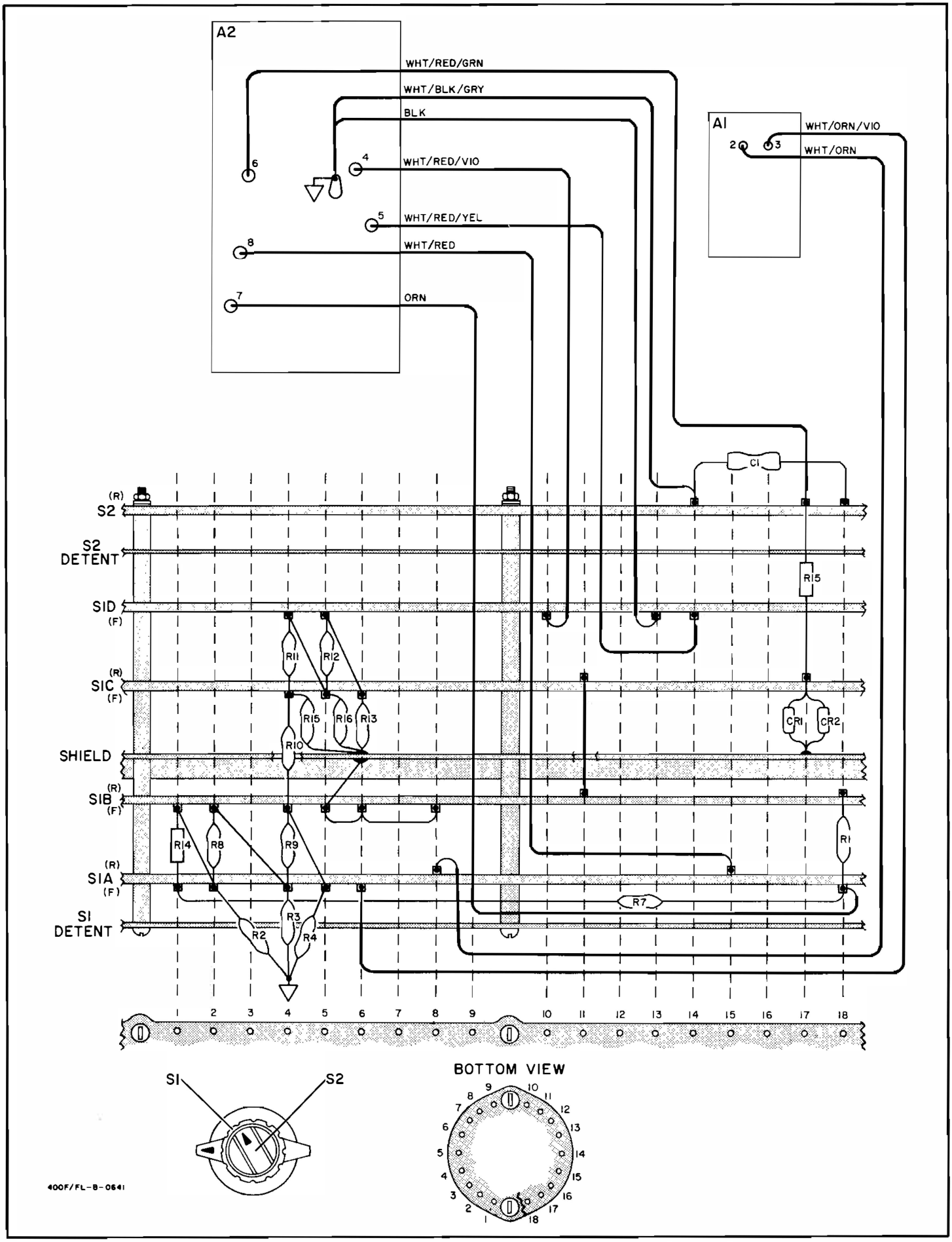
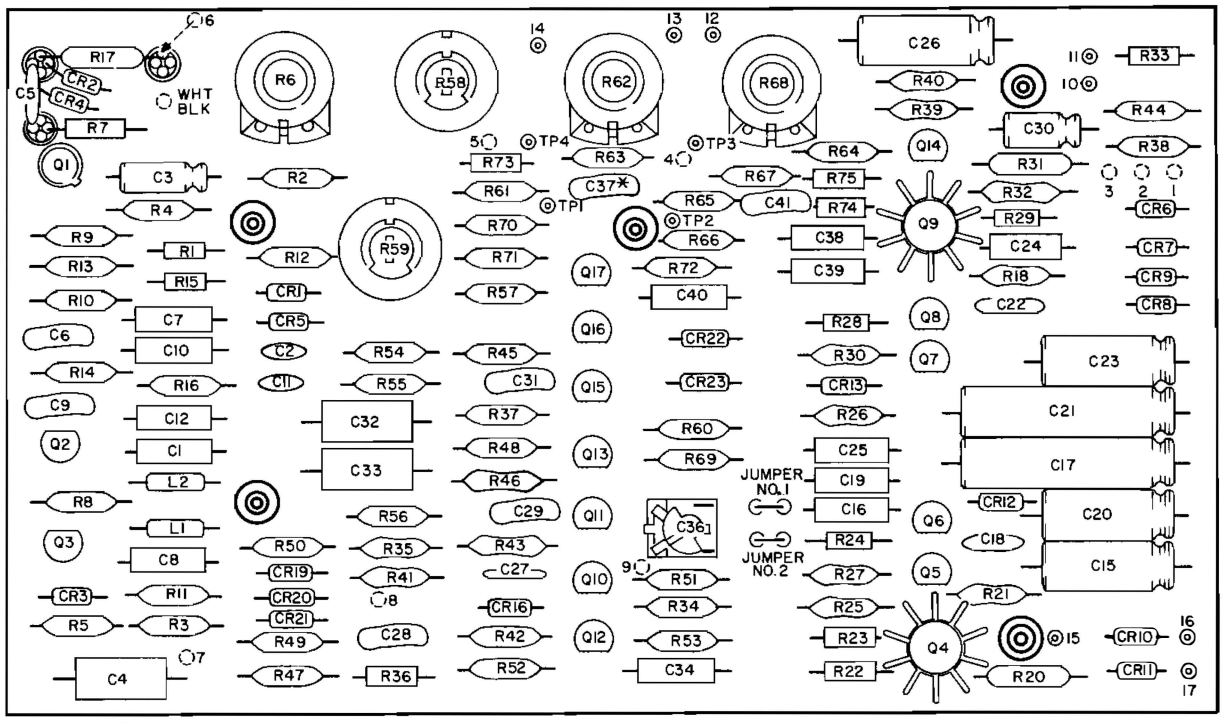
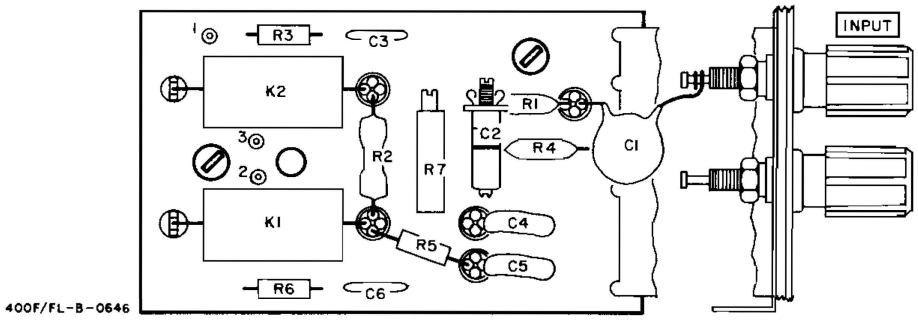


Figure 6-1. Model 400F/FL Range Switch and p/o Internal Wiring Data



A2 BOARD (-hp- Part No. 00400-66504)



A1 BOARD (-hp- Part No. 00400-66505)

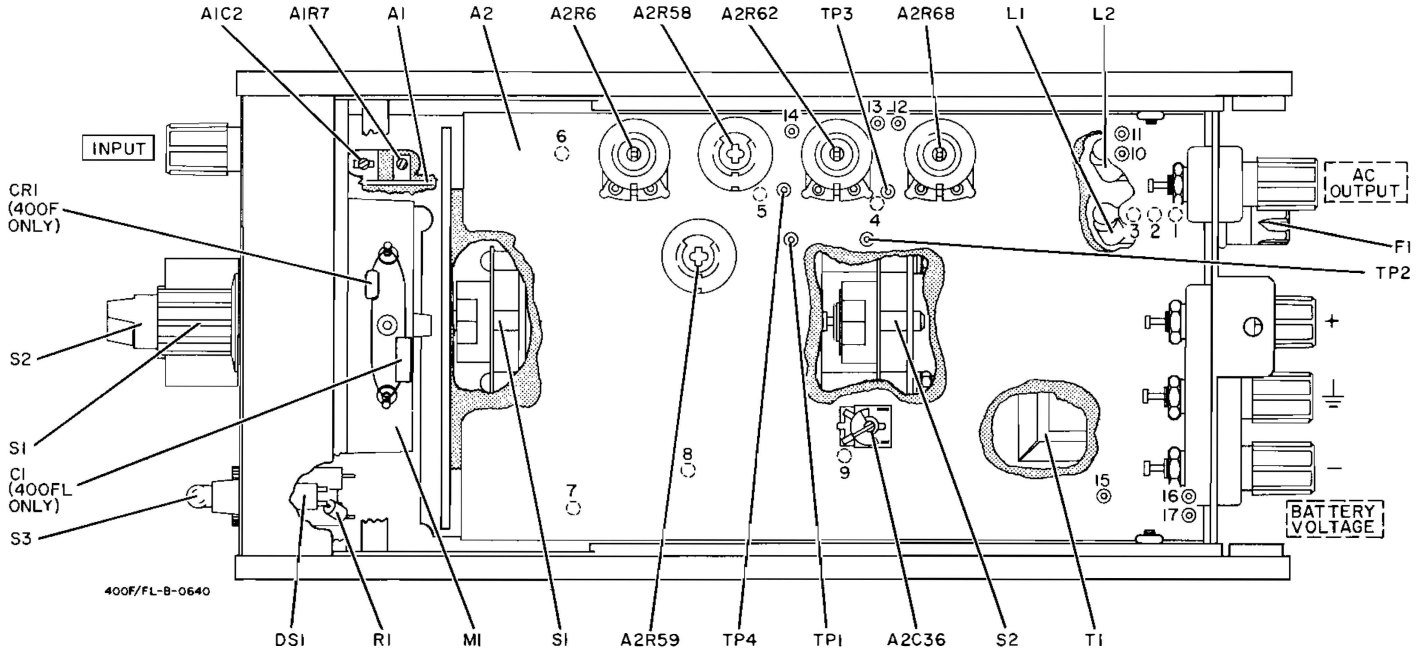


Figure 6-2. Model 400F/FL Component Location

NOTES:

1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN: PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED:
   (a) RESISTANCE IN OHMS
   (b) CAPACITANCE IN MICROFARADS
   (c) INDUCTANCE IN MILLIHENRYS
3. DENOTES ASSEMBLY.
4. DENOTES SHIELD.
5. DENOTES MAIN SIGNAL PATH.
6. DENOTES FEEDBACK PATH.
7. DENOTES FRONT PANEL MARKING.
8. DENOTES REAR PANEL MARKING.
9. DENOTES SCREWDRIVER ADJUST.
10. 918 DENOTES WIRE COLOR USING STANDARD COLOR CODE. (e.g. 918 = WHITE, BROWN, GRAY)
11. * OPTIMUM VALUE SELECTED AT FACTORY.
12. ⟨1⟩ DENOTES WIRE CONNECTION.
13. DENOTES POWER LINE GROUND.
14. DENOTES SIGNAL COMMON.

400F/FL-J-0647

01'95-1

Figure 6-3.
Model 400F/FL Schematic Diagram

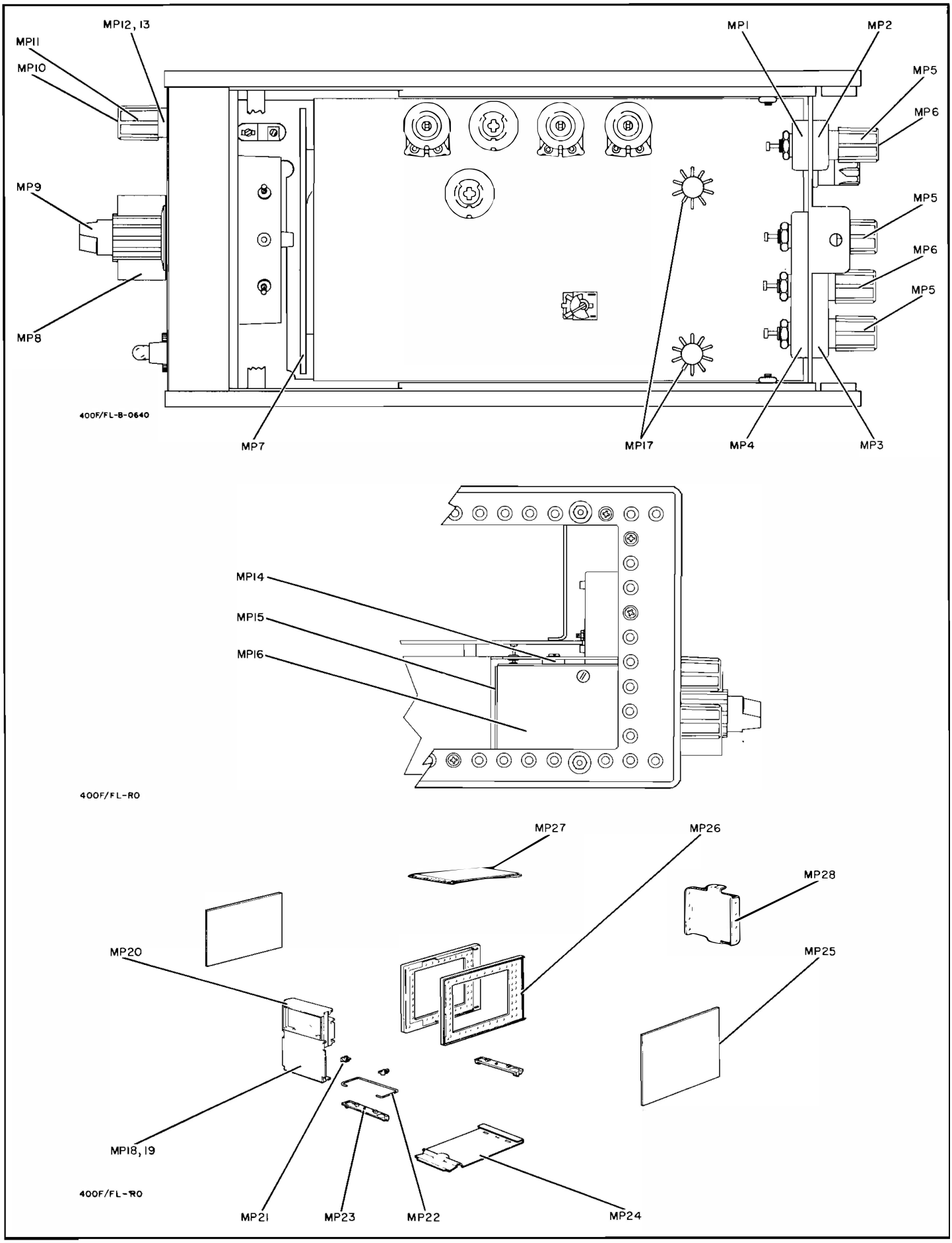


Figure 7-1. Location of Important Mechanical Parts

SECTION VII
REPLACEABLE PARTS

7-1. INTRODUCTION.

7-2. This section contains information for ordering replacement parts. Table 7-1 lists parts in alphameric order of their reference designators and indicates the description, -hp- part number of each part, together with any applicable notes, and provides the following:

a. Description of the part. (See list of abbreviations below.)

b. Typical manufacturer of the part in a five-digit code. (See Appendix A for list of manufacturers.)

c. Manufacturer's part number.

d. Total quantity used in the instrument (TQ column). Total quantity of a part is given the first time the part number appears.

7-3. Miscellaneous parts are listed at the end of Table 7-1.

7-4. ORDERING INFORMATION.

7-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. (See Appendix B for list of office locations.) Identify parts by their Hewlett-Packard part numbers.

7-6. NONLISTED PARTS.

7-7. To obtain a part that is not listed, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

REFERENCE DESIGNATORS

A	= assembly	F	= fuse	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
B	= motor	FL	= filter	Q	= transistor	W	= cable
C	= capacitor	J	= jack	R	= resistor	X	= socket
CR	= diode	K	= relay	RT	= thermistor	XF	= fuseholder
DL	= delay line	L	= inductor	S	= switch	XDS	= lampholder
DS	= device signaling (lamp)	M	= meter	T	= transformer	Z	= network
E	= misc electronic part	MP	= mechanical part				

ABBREVIATIONS

a	= amperes	elect	= electrolytic	mtg	= mounting	rot	= rotary
		encap	= encapsulated	my	= mylar	rms	= root-mean-square
bp	= bandpass					rmo	= rack mount only
bwo	= backward wave oscillator	f	= farads	NC	= normally closed	s-b	= slow-blow
		fxd	= fixed	Ne	= neon	Se	= selenium
c	= carbon			NO	= normally open	sect	= section(s)
cer	= ceramic	Ge	= germanium	NPO	= negative positive zero (zero temperature coefficient)	Si	= silicon
cmo	= cabinet mount only	grd	= ground (ed)			sil	= silver
coef	= coefficient					sl	= slide
com	= common	h	= henries	nsr	= not separately replaceable	td	= time delay
comp	= composition	Hg	= mercury			TiO_2	= titanium dioxide
conn	= connection						
crt	= cathode-ray tube	impg	= impregnated	obd	= order by description	tog	= toggle
		incd	= incandescent			tol	= tolerance
dep	= deposited	ins	= insulation (ed)			trim	= trimmer
				p	= peak	twt	= traveling wave tube
EIA	= Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by ✱ stock numbers.	K	= kilo = 1000	pc	= printed circuit board	var	= variable
						w/	= with
		lin	= linear taper	pf	= picofarads = 10^{-12} farads	W	= watts
		log	= logarithmic taper			ww	= wirewound
				pp	= peak to peak	w/o	= without
		m	= milli = 10^{-3}	piv	= peak inverse voltage	✱	= optimum value selected at factory, average value shown (part may be omitted)
		M	= megohms				
		ma	= milliamperes	pos	= position (s)		
		μ	= micro = 10^{-6}	poly	= polystyrene		
		minat	= miniature	pot	= potentiometer		
		mfgl	= metal film on glass				
		mfr	= manufacturer	rect	= rectifier		

Table 7-1. Replaceable Parts

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1	00400-66505		1	Assembly: board etched circuit includes C1 through C6 K1 through K2 R1 through R7	28480	00400-66505
A1C1	0150-0012		1	C: fxd cer 0.01 µf ±20% 1000 vdcw	56289	29C214A3
A1C2	0132-0003		1	C: var trimmer 0.7 to 3.0 pf	72982	535-016-4R
A1C3	0150-0093		2	C: fxd 0.01 µf +80% -20% 100 vdcw	91418	TA obd
A1C4	0140-0179		1	C: fxd mica 1000 pf ±2%	04062	RDM19F102G3C
A1C5	0140-0156		1	C: fxd mica 1500 pf ±2%	04062	RDM19F152G3C
A1C6	0150-0093			C: fxd 0.01 µf +80% -20% 100 vdcw	91418	TA obd
A1K1	0490-0195		1	Relay: reed high voltage	28480	0490-0195
A1K2	0490-0196		1	Relay: reed low voltage	28480	0490-0196
A1R1	0757-0346		2	R: fxd prec met flm 10 ohms ±1% 1/8 w	91637	MFF1/8 T-O obd
A1R2	0698-4128		1	R: fxd prec met flm 10 meg ±0.25%	03888	PME 70-T-2
A1R3	0684-2211		2	R: fxd comp 220 ohms ±10% 1/4 w	01121	CB-2211
A1R4	0698-4475		1	R: fxd prec met flm 9.76 K ±1% 1/8 w	91637	MFF1/8 T-O obd
A1R5	0683-0625		1	R: fxd comp 6.2 ohms ±5% 1/4 w	01121	CB-62G5
A1R6	0684-2211			R: fxd comp 220 ohms ±10% 1/4 w	01121	CB-2211
A1R7	2100-1799		1	R: var ww 500 ohms ±10% 1 w	02660	2600 Series
A2	00400-66504		1	Assembly: board etched circuit includes C1 through C12, CR19 through CR23, C15 through C34, L1, L2, C36 through C41, Q1 through Q17, CR1 through CR12, R1 through R18, CR16, R20 through R75	28480	00400-66504
A2C1	0180-0100		10	C: fxd Ta 4.7 µf ±10% 35 vdcw	56289	1500475X9035B2
A2C2	0150-0122		3	C: fxd 0.002 µf ±20% 500 vdcw	72982	801-000-Y55-202M
A2C3	0180-0119		1	C: fxd Al elect 1 µf +75% -10% 25 vdcw	56289	30D105G025BA2-DSM
A2C4	0180-0137		2	C: fxd Ta elect 100 µf ±20% 10 vdcw	56289	150D107X0010R2
A2C5	0150-0084		1	C: fxd cer 0.1 µf +80% -20% 50 vdcw	56289	33C41 obd
A2C6	0160-2024		1	C: fxd 75 pf ±5% 500 vdcw	28480	0160-2024
A2C7	0180-0106			C: fxd Ta elect 60 µf ±20% 6 vdcw	56289	150D606X0006B2
A2C8	0180-0100			C: fxd Ta 4.7 µf ±10% 35 vdcw	56289	1500475X9035B2
A2C9	0140-0198		1	C: fxd mica 200 pf ±5% 300 vdcw	04062	RDM15F201J3C
A2C10	0180-0100			C: fxd Ta 4.7 µf ±10% 35 vdcw	56289	1500475X9035B2
A2C11	0150-0122			C: fxd 0.002 µf ±20% 500 vdcw	72982	801-000-Y55-202M
A2C12	0180-0100			C: fxd Ta 4.7 µf ±10% 35 vdcw	56289	1500475X9035B2
A2C13, A2C14				Not Assigned		
A2C15	0180-0061		3	C: fxd Al elect 100 µf +75% -10% 15 vdcw	56289	30D107G015DC2-DSM
A2C16	0180-0100			C: fxd Ta 4.7 µf ±10% 35 vdcw	56289	1500475X9035B2
A2C17	0180-1819		2	C: fxd Al elect 100 µf +75% -10% 50 vdcw	56289	30D107G050DH2-DSM
A2C18	0150-0024		2	C: fxd cer 0.02 µf +80% -20% 600 vdcw	72982	841-000-25U-203Z
A2C19	0180-0100			C: fxd Ta 4.7 µf ±10% 35 vdcw	56289	1500475X9035B2
A2C20	0180-0061			C: fxd Al elect 100 µf +75% -10% 15 vdcw	56289	30D107G015DC2-DSM
A2C21	0180-1819			C: fxd Al elect 100 µf +75% -10% 50 vdcw	56289	30D107G050DH2-DSM
A2C22	0150-0024			C: fxd cer 0.02 µf +80% -20% 600 vdcw	72982	841-000-25U-203Z
A2C23	0180-0061			C: fxd Al elect 100 µf +75% -10% 15 vdcw	56289	30D107G015DC2-DSM
A2C24, A2C25	0180-0100			C: fxd Ta 4.7 µf ±10% 35 vdcw	56289	1500475X9035B2
A2C26	0180-0058		1	C: fxd Al elect 50 µf +75% -10% 25 vdcw	56289	30D506G025CC2-DSM

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A2C27	0150-0122			C: fxd 0.002 μf ±20% 500 vdcw	72982	801-000-Y55-202M	
A2C28	0140-0195		1	C: fxd 130 pf mica ±5% 300 vdcw	04062	RDM15F131J3C	
A2C29	0140-0190		1	C: fxd mica 39 pf ±5%	04062	RDM15E390J3C	
A2C30	0180-0224		1	C: fxd Al elect 10 μf 15 vdcw	56289	30D106G015BA4	
A2C31	0140-0208		1	C: fxd mica 680 pf ±5% 300 vdcw	04062	RDM15F681J3C	
A2C32, A2C33	0180-0137			C: fxd Ta elect 100 μf ±20% 10 vdcw	56289	150D107X0010R2	
A2C34	0180-0100			C: fxd Ta 4.7 μf ±10% 35 vdcw	56289	1500475X9035B2	
A2C35				Not Assigned			
A2C36	0121-0127		1	C: var 1.7 to 11 pf single section	74970	189-5-5	
A2C37*	0160-0205		1	C: fxd mica 10 pf ±5% 500 vdcw	56289	73P73P223016	
A2C38, A2C39	0180-0393		2	C: fxd Ta 39 μf ±10% 10 vdcw	56289	150D396X9010B2	
A2C40	0180-0100			C: fxd Ta 4.7 μf ±10% 35 vdcw	56289	1500475X9035B2	
A2C41	0140-0149		1	C: fxd mica 470 pf ±5% 300 vdcw	04062	DM15F471J	
A2CR1	1902-0022		2	Diode: breakdown 2.67 v ±10% 4 mw	07910	CD35540	
A2CR2	1901-0044		2	Diode: Si 50 ma at +1 v 10 na reverse current 50 wiv 2 pf	07910		obd
A2CR3	1901-0040		10	Diode: Si 30 ma at +10 v piv 12 pf 2 ns	07910	CD6319	obd
A2CR4	1901-0044			Diode: Si 50 ma at +1 v 10 na reverse current 50 wiv 2 pf	07910		obd
A2CR5	1902-0022			Diode: breakdown 2.67 v ±10% 4 mw	07910	CD35540	
A2CR6 through A2CR11	1901-0033		6	Diode: Si 100 ma at 1 v 180 wiv 1N485B	93332	D6238	obd
A2CR12	1901-0040			Diode: Si 30 ma at +10 v piv 12 pf 2 ns	07910	CD6319	obd
A2CR13	1902-3125		1	Diode: Si 6.98 v ±2% 400 mw	07263		obd
A2CR14, A2CR15				Not Assigned			
A2CR16	1901-0040			Diode: Si 30 ma at +10 v piv 12 pf 2 ns	07910	CD6319	obd
A2CR17, A2CR18				Not Assigned			
A2CR19 through A2CR21	1901-0040			Diode: Si 30 ma at +10 v piv 12 pf 2 ns	07910	CD6319	obd
A2CR22, A2CR23	1901-0027		2	Diode: Si 1N4392	73293		obd
A2L1, A2L2	9140-0047		2	Inductor: fxd 20 μh ±10%	99848	H 51074020	
A2Q1	1855-0029		1	Transistor: FET P channel	61637	F5035	
A2Q2	1854-0215		7	Transistor: Si NPN 2N3904	04713	2N3904	
A2Q3	1853-0036		7	Transistor: Si PNP 2N3906	04713	2N2906	
A2Q4	1854-0039		2	Transistor: Si NPN 2N3052	86684	2N3053	
A2Q5, A2Q6	1854-0215			Transistor: Si NPN 2N3904	04713	2N3904	
A2Q7, A2Q8	1853-0036		6	Transistor: Si PNP 2N3906	04713	2N3906	
A2Q9	1854-0039			Transistor: Si NPN 2N3053	86684	2N3053	
A2Q10	1854-0215			Transistor: Si NPN 2N3904	04713	2N3904	
A2Q11	1853-0036			Transistor: Si PNP 2N3906	04713	2N3906	
A2Q12 through A2Q14	1854-0215			Transistor: Si NPN 2N3904	04713	2N3904	
A2Q15 through A2Q17	1853-0036			Transistor: Si PNP 2N3906	04713	2N3906	
A2R1	0698-4121		5	R: fxd prec comp 11.3 K ±1% 1/8 w	75042	CEA T-O	obd
A2R2	0757-0474		4	R: fxd prec met flm 243 K ±1% 1/8 w	91637	MFF-1/8 T-O	obd
A2R3	0757-0434		12	R: fxd prec met flm 3.65 K ±1% 1/8 w	91637	MFF-1/8 T-O	obd
A2R4	0698-3178		2	R: fxd prec met flm 487 ohms ±1% 1/8 w	91637	MFF-1/8 T-O	obd
A2R5	0698-4196		5	R: fxd prec met flm 1.07 K ±1% 1/8 w	91637	MFF-1/8 T-O	obd
A2R6	2100-0095		1	R: var comp lin 100 K ±30% 0.10 w	71450	UPE 70RE (hp)	
A2R7	0686-2265		1	R: fxd comp 22 meg ±5% 1/2 w	01121	EB-2265	
A2R8	0757-0410		1	R: fxd prec met flm 301 ohms ±1% 1/8 w	91637	MFF-1/8 T-O	obd

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2R9	0757-0434			R: fxd prec met film 3.65 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R10	0698-3510		2	R: fxd prec met film 453 ohms ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R11	0698-4457		1	R: fxd prec met film 576 ohms ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R12	0757-0474			R: fxd met film 243 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R13	0757-0434			R: fxd prec met film 3.65 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R14	0698-4396		2	R: fxd prec met film 80.6 ohms ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R15	0698-4121			R: fxd prec met film 11.3 K ±1% 1/8 w	75042	CEA T-O obd
A2R16	0757-0428		1	R: fxd prec met film 1.62 K ±1% 1/8 w	75042	CEA T-O obd
A2R17	0757-0808		1	R: fxd prec met film 301 ohms ±1% 1/2 w	75042	CEC T-O obd
A2R18	0757-0401		5	R: fxd prec met film 100 ohms ±1% 1/8 w	75042	CEA T-O obd
A2R19				Not Assigned		
A2R20	0757-0794		2	R: fxd prec met film 68.1 ohms ±1% 1/2 w	91637	MFF-1/2 T-O obd
A2R21	0698-4196			R: fxd prec met film 1.07 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R22, A2R23	0757-0434			R: fxd prec met film 3.65 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R24	0757-0290		2	R: fxd prec met film 6.19 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R25	0698-4121			R: fxd prec met film 11.3 K ±1% 1/8 w	75042	CEA T-O obd
A2R26	0757-0447		1	R: fxd prec met film 16.2 K ±1% 1/8 w	75042	CEA T-O obd
A2R27	0698-3155		1	R: fxd prec met film 4.64 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R28, A2R29	0757-0434			R: fxd prec met film 3.65 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R30	0698-3156		4	R: fxd prec met film 14.7 K ±1% 1/8 w	75042	CEA T-O obd
A2R31	0757-0794			R: fxd prec met film 68.1 ohms ±1% 1/2 w	91637	MFF-1/2 T-O obd
A2R32	0698-4196			R: fxd prec met film 1.07 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R33	0757-0474			R: fxd met film 243 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R34	0757-0401			R: fxd met film 100 ohms ±1% 1/8 w	75042	CEA T-O obd
A2R35, A2R36	0757-0434			R: fxd prec met film 3.65 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R37	0757-0438		1	R: fxd prec met film 5.11 K ±1% 1/8 w	75042	CEA T-O obd
A2R38	0698-3156			R: fxd prec met film 14.7 K ±1% 1/8 w	75042	CEA T-O obd
A2R39	0698-3510			R: fxd prec met film 453 ohms ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R40	0698-3438		2	R: fxd prec met film 147 ohms ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R41	0698-4196			R: fxd prec met film 1.07 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R42	0757-0401			R: fxd prec met film 100 ohms ±1% 1/8 w	75042	CEA T-O obd
A2R43	0757-0408		1	R: fxd prec met film 243 ohms ±1% 1/8 w	75042	CEA T-O obd
A2R44	0698-3156			R: fxd prec met film 14.7 K ±1% 1/8 w	75042	CEA T-O obd
A2R45	0757-0277		1	R: fxd prec met film 49.9 ohms ±1%, 1/8 w	91637	MFF-1/2 T-2
A2R46	0757-0441		1	R: fxd prec met film 8.25 K ±1% 1/8 w	75042	CEA T-O obd
A2R47	0698-3157		2	R: fxd prec met film 19.6 K ±1% 1/8 w	75042	CEA T-O obd
A2R48	0757-0401			R: fxd prec met film 100 ohms ±1% 1/8 w	75042	CEA T-O obd
A2R49	0698-3156			R: fxd prec met film 14.7 K ±1% 1/8 w	75042	CEA T-O obd
A2R50	0757-0434			R: fxd prec met film 3.65 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R51	0698-4121			R: fxd met film 11.3 K ±1% 1/8 w	75042	CEA T-O obd
A2R52	0757-0444		1	R: fxd prec met film 12.1 K ±1% 1/8 w	75042	CEA T-O obd
A2R53	0698-4121			R: fxd met film 11.3 K ±1% 1/8 w	75042	CEA T-O obd
A2R54	0757-0401			R: fxd prec met film 100 ohms ±1% 1/8 w	75042	CEA T-O obd
A2R55	0698-3438			R: fxd prec met film 147 ohms ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R56	0698-3450		2	R: fxd prec met film 42.2 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R57	0757-0408		1	R: fxd prec met film 243 ohms ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R58, A2R59	2100-0290		2	R: var prec ww 100 ohms ±2% 1-1/2 w	11237	110 obd
A2R60	0698-4396			R: fxd prec met film 80.6 ohms ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R61	0698-3157			R: fxd prec met film 19.6 K ±1% 1/8 w	75042	CEA T-O obd
A2R62	2100-0240		1	R: var ww 50 ohms ±20% 1-1/2 w	11237	110 obd
A2R63	0757-0161		1	R: fxd prec 604 ohms ±1% 1/8 w	28480	0757-0161
A2R64	0698-3434		1	R: fxd 34.8 ohms ±1% 1/8 w	75042	CEA T-O obd
A2R65	0757-0381		1	R: fxd prec met film 15 ohms ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R66	0757-0384		1	R: fxd prec met film 20 ohms ±1% 1/8 w	91637	MFF-1/8 T-O obd

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2R67	0757-0346			R: fxd prec met film 10 ohms ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R68	2100-0277		1	R: var comp lin 100 ohms ±2% 0.3 w	71450	Type UPE65 CV
A2R69	0698-4196			R: fxd prec met film 1.07 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R70	0698-3450			R: fxd met film 42.2 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R71	0757-0290			R: fxd prec met film 6.19 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R72	0698-3178			R: fxd prec met film 487 ohms ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R73	0757-0474			R: fxd prec met film 243 K ±1% 1/8 w	91637	MFF-1/8 T-O obd
A2R74, A2R75	0757-0434		2	R: fxd prec met film 3.65 K ±1%, 1/8 w (400FL Only, A2R75)	91637	MFF-1/8 T-O obd
C1	0180-0106			C: fxd Ta 60 μf ±20% 6 vdcw (400FL Only)	56289	150D606X006B2
CR1	1901-0040			Diode: Si (400F Only) 30 ma at +10 v piv 12 pf 2 ns	07910	CD6319 obd
DS1	1450-0048		1	Lamp: pilot A165 red transparent	72765	599-124
F1	2110-0017		1	Fuse: 0.15 amp slow-blow 115/230 v	75915	313.150
J1 through J3				See MP5, MP6, MP10, and MP11		
J4	1251-0148		1	Connector: ac power cord receptacle	87930	H-1061-2
L1, L2	9140-0041		2	Inductor: fxd 2.5 mh ±10%	95265	SA-2500-I
M1	1120-0918		1	Meter: linear (400F Only)	28480	1120-0918
M1	1120-0919		1	Meter: log (400FL Only)	28480	1120-0919
M1	1120-1273		1	Meter: linear (400F Only, Option 01)	28480	1120-1273
MP1	0340-0090		1	Insulator: 2 hole BP with locating key	28480	0340-0090
MP2	0340-0086		1	Insulator: 2 hole without locating key	28480	0340-0086
MP3	0340-0087		1	Insulator: 3 hole BP in line	28480	0340-0087
MP4	0340-0091		1	Insulator: 3 hole BP with locating key	28480	0340-0091
MP5	1510-0010		3	Binding Post Ass'y: red battery voltage and ac output	28480	1510-0010
MP6	1510-0011		2	Binding Post Ass'y: black rear panel	28480	1510-0011
MP7	00400-00605		1	Shield: meter	28480	00400-00605
MP8	0370-0113		1	Knob: bar with one arrow part of S1 black	28480	0370-0113
MP9	0370-0115		1	Knob: bar red with pointer part of S2	28480	0370-0115
MP10	1510-0035		1	Binding Post Ass'y: black INPUT	28480	1510-0035
MP11	1510-0036		1	Binding Post Ass'y: red INPUT	28480	1510-0036
MP12	0340-0099		2	Insulator: binding post (single)	28480	0340-0099
MP13	0340-0100		1	Insulator: binding post (single)	28480	0340-0100
MP14	0340-0109		6	Insulator: nylon threaded	02768	212-160402-00-0101
MP15	00400-05502		1	Can: shield	28480	00400-05502
MP16	00400-04102		1	Cover: attenuator	28480	00400-04102
MP17	1205-0033		2	Semiconductor: heat dissipator	05820	NF-207
MP18	00400-00207		1	Panel: front (400FL Only)	28480	00400-00207
MP19	00400-00208		1	Panel: front (400F Only)	28480	00400-00208
MP20	5020-0704		1	Trim: meter third mod	28480	5020-0704
MP21	5040-0700		2	Hinge	28480	5040-0700
MP22	1490-0031		1	Stand: 1/3 mod tilt	91260	obd
MP23	5060-0727		2	Foot Ass'y: 1/3 mod	28480	5060-0727
MP24	5000-0711		1	Cover Ass'y: bottom 5 x 11 sm	28480	5000-0711
MP25	5000-0703		2	Cover Ass'y: side 6 x 11 sm	28480	5000-0703
MP26	5060-0703		2	Frame: sub mod 6 x 11	28480	5060-0703
MP27	5060-0709		1	Cover Ass'y: top 5 x 11 sm	28480	5060-0709
MP28	00400-00206		1	Panel: rear	28480	00400-00206
R1	0687-3331		1	R: fxd comp 33 K ±10% 1/2 w	01121	EB-3331
S1	00400-61903		1	Switch Assembly: range includes C1 CR1, CR2 R1 through R15	28480	00400-61903
S1C1	0160-0207		1	C: fxd mylar 0.01 μf ±5% 200 v	56289	192P10352
S1CR1, S1CR2	1901-0040			Diode: Si 30 ma at +10 v piv 12 pf 2 ns	07910	CD6319 obd

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
S1R1	0757-0167		1	R: fxd prec 143 ohms ±1% 1/4 w	19701	MF6C T-O 0bd
S1R2 through S1R6	0698-4118		5	R: fxd met flm prec 277.48 ohms ±0.1% 1/4 w	75042	CEB T-3 obd
S1R7 through S1R12	0698-4119		6	R: fxd met flm prec 410.26 ohms ±0.1% 1/4 w	75042	CEB T-3 obd
S1R13	0698-4117		1	R: fxd met flm prec 189.72 ohms ±0.1% 1/4 w	75042	CEB T-3 obd
S1R14, S1R15	0687-1501		2	R: fxd comp 150 ohms ±10% 1/2 w	28480	0687-1501
S2				P/o RANGE switch assembly S1		
S3	3101-0036		1	Switch: toggle SPST On-None-Off 3 amps 25 v	88140	8928K61
S4	3101-0033		1	Switch: slide DPDT 115/230 v	42190	4633 obd
T1	9100-1321		1	Transformer	28480	9100-1321
TP1 through TP4	0360-0435		4	Terminal: board silver plated brass	12284	1012-3
W1	00400-61602		1	Cable 1 : power	28480	00400-61602
W2	00400-61603		1	Cable 2 : meter	28480	00400-61603
XF1	1400-0084		1	Holder: fuse extractor post type	75915	342014
				MISCELLANEOUS		
	8120-0078		1	Cord: set power smooth black extra limp 7.5 ft. long	70903	KH-4147
	00400-90003		1	Manual: operating and service	28480	00400-90003

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

Code No.	Manufacturer	Address
80589	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N. Y.
00334	Hamdall Co.	Colton, Calif.
00335	Vesbec Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Capacitor Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chase-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04062	Elmenco Products Co.	New York, N.Y.
04222	HRQ Divisional Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04358	Precision Paper Tube Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04551	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Fulton Co., Inc., Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
04796	Sequoia Wire & Cable Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P. M. Motor Company	Chicago 40, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (Fig 6 Electrical Specs. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tuttle Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metropolitan Telecommunications Corp., Metro Cap. Division	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06475	Western Coil Inc.	Inglewood, Calif.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06751	D. S. Semcor Div. Bird Electronic Corp. of America	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Feinmetall Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07260	Fairchild Semiconductor Corp.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Bircher Corp.	Los Angeles, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07956	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08265	Sinnn, Delbert, Co.	Pomona, Calif.
08356	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co., Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C. B. S., Inc.	Lowell, Mass.
08984	Mel-Ram	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Aladdin Electronics	San Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09594	The Bristol Co.	Waterbury, Conn.
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Te-Tel, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronics, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N.J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13606	Thermalloy	Dallas, Texas
13396	Telefunken (G.m.b.H.)	Hannover, Germany
13835	Midland Mfg. Co.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14288	American Components, Inc.	Conshohocken, Pa.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
14936	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co. Inc.	Brooklyn, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15909	The Bevan Co.	Livingston, N.J.
16037	Spruce Pine Mica Co.	Spruce Pine, N. C.
16352	Computer Diode Corp.	Lodi, N. J.
16588	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Ind.
17109	Thermometrics Inc.	Canoga Park, Calif.
17474	Frame Company	Mountain View, Calif.
18486	Radio Industries	Des Plaines, Ill.
18583	Curtis Instrument Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y.
21520	Faostool Metallurgical Corp.	No. Chicago, Ill.
21335	The Falon Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division Nela Park,	Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Gabriel Fila Co. of America, Inc.	Carlsbad, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
35196	Slaymych Corp.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
48970	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
53743	Ward Leonard Electric	Mt. Vernon, N.Y.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonnawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
59730	Thomas & Betts Co.	Elizabeth 1, N.J.
60741	Trapolene Electrical Inc.	Bellaire, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Instr., Div. of Daystrom, Inc.	Newark, N.J.
66295	Wilco Manufacturing Co.	Chicago 23, Ill.
66348	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70319	Almetal Screw Prod. Co., Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
71563	Amperite Co., Inc.	New York, N.Y.
71707	Beldee Mfg. Co.	Chicago, Ill.
71998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainview, L.I., Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71435	Chicago Condenser Corp.	Chicago, Ill.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71487	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72982	Eitel-McCullough, Inc.	San Bruno, Calif.
72136	Electro Motive Mfg. Co., Inc.	Williamsville, Conn.
72707	Cole Coil Co., Inc.	Providence, R.I.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72699	General Instrument Corp., Semiconductor Div.	Newark, N.J.
72755	Gicard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert W. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Heliopot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Philips Co. Inc.	Hicksville, N.Y.
73490	Beckman Helipot Corp.	So. Pasadena, Calif.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Prod. Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73836	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	James, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75376	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76588	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio,
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77075	Pacific Wells Co.	San Francisco, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77250	Ploedl Mfg. Co.	Chicago, Ill.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Sigma Instrument Corp.	New York, N.Y.
78290	Stackpole-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bitcast & Co.	Chicago, Ill.
78471	Talley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78780	Transformer Engineers	Pasadena, Calif.
78947	Utemite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80120	Times Facsimile Corp.	New York, N.Y.
80191	Electronic Industries Association, Any brand tube meeting EIA standards	Washington, D.C.
80207	United Switch, Div. of W.L. Maxson Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns, Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 15, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80589	Avery Adhesive Label Corp.	Monrovia, Calif.
80589	Hammarlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81337	Winchester Electronics Co., Inc.	Norwalk, Conn.

From: FSC. Handbook Supplements
H4-1 Dated DECEMBER 1964
H4-2 Dated MARCH 1962

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

Code No.	Manufacturer	Address
81349	Military Specification	********
81415	Wilbor Products, Inc.	Cleveland, Ohio
81483	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	ElSegundo, Calif.
81541	The Airpax Products Co.	Cambridge, Mass.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Stokes, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.
82209	Magnetic Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.,	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83169	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Humboldt, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Nebr.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.N. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fiberglass Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	Seattle, Wash.
87930	Tower Mfg. Corp	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Greyhar Electric Co.	Oakland, Calif.
89462	Waldes Kohinoor, Inc.	Cambridge, Mass.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Conmar Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	August Brothers', Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	KF Development Co.	Redwood City, Calif.
91929	Minneapolis-Honeywell Hollustor Co., Microsemicd Div.	Freeport, Ill.
91951	Naben-Bhas. Spring Co.	Oakland, Calif.
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94272	Sealtron Div. OIS. Chester Corp.	Lester, Pa.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94330	Wire Cloth Products Inc.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95023	Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95296	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
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00000	Micro Tools and Die	Los Angeles, Calif.
00004	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
00009	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
00002	Willow Leather Products Corp.	Newark, N.J.
00004	British Radio Electronics Ltd.	Washington, D.C.
00004	ETA	England
00004	Indiana General Corp., Elect. Div.	Indiana
00005	Precision Instrument Components Co.	Van Nuys, Calif.
00004	Rubber Eng. & Development	Hayward, Calif.
00004	Arnold Manufacturing Co.	San Jose 27, Calif.
00004	Coaltron	Oakland, Calif.
00005	Council of Elgin Watch Co.	Burbank, Calif.
00004	California Eastern Lab.	Burlingame, Calif.
00004	S.K. Smith Co.	Los Angeles 43, Calif.

From: FSC, Handbook Supplements
H4-1 Dated DECEMBER 1964
H4-2 Dated MARCH 1962

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MANUAL BACKDATING CHANGES

Model MODEL 400F/FL

Name AC VOLTMETER

Prefix

This manual backdating sheet makes this manual applicable to earlier instruments. Instrument-component values that dif from those in the manual, yet are not listed in the backdating sheet, should be replace ing the part number given in the manual.

Instrument Serial Prefix	Make Manual Changes
617-00450 and below	1, 2, 3, 4, 6, 8
617-00451 thru 617-01525	2, 3, 4, 6, 8
734-01526 thru 734-02775	3, 4, 6, 8
912-02776 thru 912-02875	4, 5, 6, 8
912-02876 thru 912-02975	5, 6
912-02976 thru 912-03475	6

CHANGE NO. 1

Instrument Serial Prefix	Make Manual Changes
All	7

CHANGE NO. 2

Delete diodes A2CR24 through A2CR28 from Figure 7-2, Figure 7-3, and Table 6-1.

Paragraph 5-30(b), change "+ 6 V" to "- 6 V."

Figure 7-3:

Change PREAMPLIFIER schematic to the following:

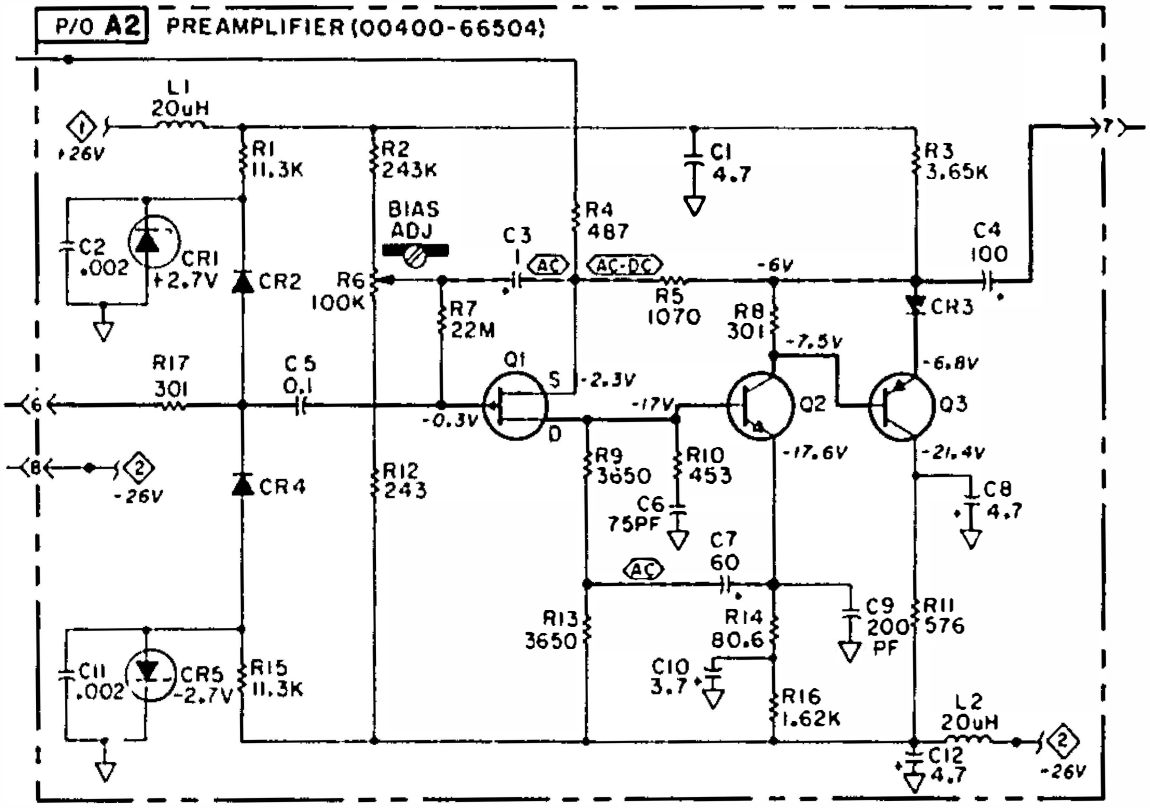


Table 6-1:
Change A2Q1 to 1855-0052 FET P channel.
Change A2Q2 to 1854-0314 Si NPN.
Change A2Q3 to 1853-0036 Si PNP.

CHANGE NO. 3

Figure 7-3 and Table 6-1:

A2R33, 0757-0474, R:fxd prec met flm 243 kΩ ± 1% 1/8W
A2R39, 0698-3510, R:fxd prec met flm 453 Ω ± 1% 1/8W
A2R40, 0698-3438, R:fxd prec met flm 147 Ω ± 1% 1/8W

CHANGE NO. 4

Figure 7-3 and Table 6-1:

A2R63, 0757-0417, R:fxd prec met flm 562 Ω ± 1% 1/8W

CHANGE NO. 5

Figure 7-3 and Table 6-1:

A2R33, 0698-4125, R:fxd prec met flm 953 Ω ± 1% 1/8W
A2R39, 0698-4422, R:fxd prec met flm 1.27 kΩ ± 1% 1/8W
A2R40, 0698-3488, R:fxd prec met flm 442 Ω ± 1% 1/8W

CHANGE NO. 6

Table 6-1:

J4, 1251-0148, Connector: ac power cord receptacle, 87930, H-1061-2
MP24, 00400-00206, Panel: rear, -hp-
8120-0078, Cord: power

CHANGE NO. 7

The part numbers listed are for brown instruments. The part numbers for blue instruments are shown below.

MP22	00400-64102	Cover Assy: top
MP25	5000-0703	Cover Assy: side
MP26	5000-0711	Cover Assy: bottom
MP30	00400-00207	Panel: front (400FL)
	00400-00208	Panel: front (400F)
MP31	5020-0704	Trim: meter (400FL)
	5030-5388	Trim: meter (400F)

CHANGE NO. 8

Table 6-1:

A2R63*, 0698-4468, R:fxd flm 1.13 kΩ ± 1% 1/8W

HEWLETT hp PACKARD GmbH

MANUAL CHANGES

Manual for Model Number	400F/FL
Manual printed on	July 1974
Manual Part Number	00400-90016

Make all ERRATA corrections.

Check the following table for your instrument serial prefix/serial number and make the listed changes to your manual.

▶ New Item

Serial Prefix or Serial Number		Manual Changes	Serial Prefix or Serial Number	Manual Changes
1212G01321	and above	1		
1202G01426	and above	1-2		
1202G01591	and above	1-3		
1641G01681	and above	1-4		

MODEL 400F/FL

INDEX OF MANUAL CHANGES

MANUAL CHANGE	A1	A2	FRAME				
1	C1,2,3,6	C5,18,22, C41,6 CR22,Q3 R5,10,60 R69	MP24,30, MP31,32 DS1, S3				
2			MP5				
3			MP1,2,3,4 MP6,7,12, MP13,24 Binding - Post				
4			C2,S3,4 MP24				

MANUAL CHANGE 1

On Table 6-1, change the Table of Replaceable Parts to read:

A1C1	0160-2902	C:FXD CER 0.01UF + 20% 1000V
A1C2	0132-0003	C:VAR TRIMMER 3.0PF
A1C3,6	0160-2930	C:FXD CER 0.01UF +80 -20% 100V
A2C5	0160-2914	C:FXD CER 0.1UF +80 -20% 50V
A2C18,22	0160-2897	C:FXD CER 0.02UF +80 -20% 600V
A2C41	0160-2940	C:FXD MICA 470PF ±5% 300V
A2C6	DELETE	
A2R10	DELETE	
A2CR22	1901-0535	DIODE HOT CARRIER
A2Q3	1854-0329	TRANSISTOR SI NPN
A2R5	0698-4125	R:FXD FILM 953 OHM + 1% 1/8W
A2R60*	0757-0392	VALUE SELECTED AT FACTORY, LOWEST VALUE 43,2 OHM.
A2R69	0757-1097	R:FXD FILM 1.2K ± 1% 1/8W
MP24	00400-10006	PANEL REAR
MP30	00400-00102	PANEL FRONT
MP31	5020-7633	TRIM METER
MP32	5060-0703	BRACKET: COVER RETAINER
DS1	1450-0419	LAMP - PILOT
S3	3101-0030	SWITCH TOGGLE

For Instruments equipped with German "Schuko" Power cable change power cord to 8120-1689

MANUAL CHANGE 2

On Table 6-1, change the Holder Fuse 1400-0084 to the following Components:

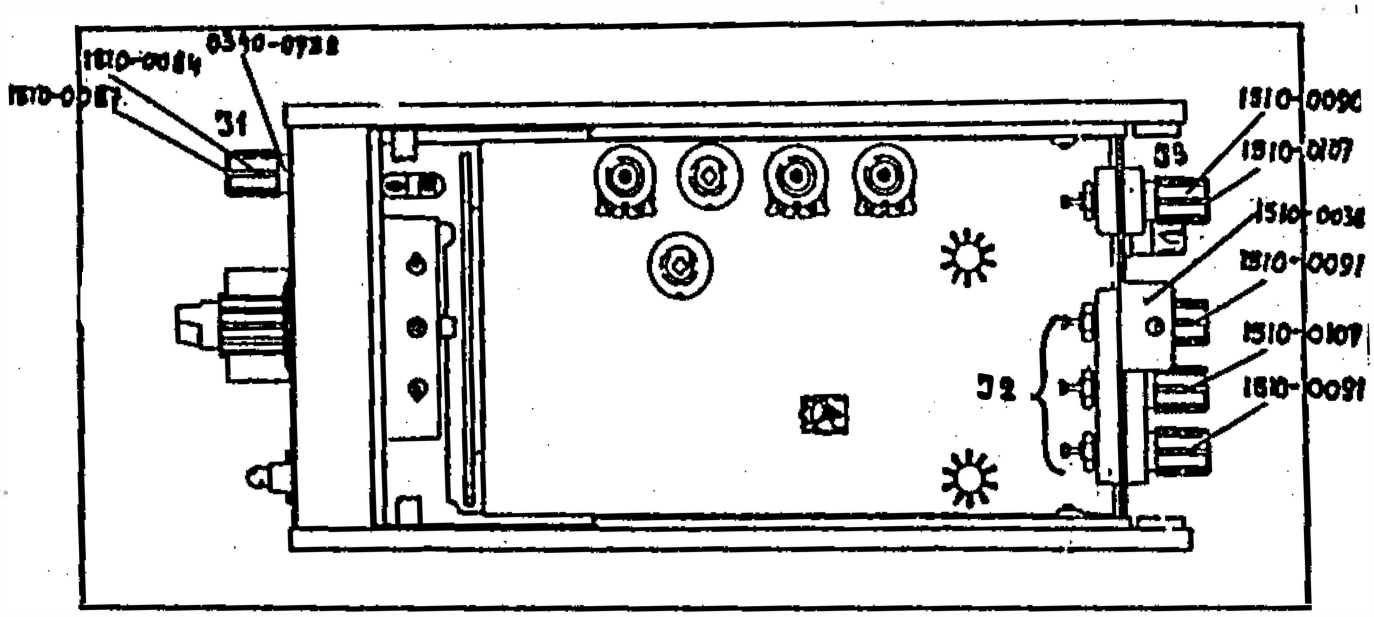
MP5	2110-0470	FUSEHOLDER BODY
MP5	1400-0090	WASHER NEOPRENE
MP5	2190-0054	WASHER LOCK
MP5	2110-0467	NUT HEX (METALLIC)
MP5	2110-0465	FUSEHOLDER CAP

MANUAL CHANGE 3

On Table 6-1, change the Table of Replaceable Parts to read:

MP24	00400-60212	PANEL ASSY REAR
MP1,2,3,4,6,7,12,13	DELETE	
	0340-0732	INSULATOR BINDING POST
	1510-0084	BINDING POST
	1510-0087	BINDING POST
	1510-0090	BINDING POST
	1510-0091	BINDING POST
	1510-0107	BINDING POST
	2950-0144	NUT NYLON, 3/8 - 32

NOTE: The components listed above can be identified on the diagram shown below:



MANUAL CHANGE 4

On Table 6-1, change the Table of Replaceable Parts to read:

C2	0160-4048	C:FXD .022UF ACROSS J4
S3	3101-2147	SW SPST
S4	3101-1740	SW SLIDE
MP24	00400-00246	PANEL ASSY REAR
	1510-0038	BINDING POST

MANUAL CHANGES

MODEL 400F/FL

AC VOLTMETER

Manual Part No. 00400-90016

■ New or Revised Item

CHANGE NO. 1 applies to serial number 0950A-08336 and above for the 400F and serial number 0950A-08286 and above for the 400FL.

Page 6-7, Table 6-1. Add to the replaceable parts the following:

-hp- Part No. 1510-0038, TQ:1, description:BDG post-single (located on rear panel).

-hp- Part No. 7120-4609, TQ:1 description: Warning Label.

CHANGE NO 2. applies to serial number 0950A-08726 and above for the 400F and serial number 0950A-08766 and above for the 400FL.

Page 3-0 and 3-1, Figure 3-1 and 3-2. Change ⏚ to ⊥

Page 6-2, Figure 6-1. Change rear panel drawing to Figure CS1 of change sheet.

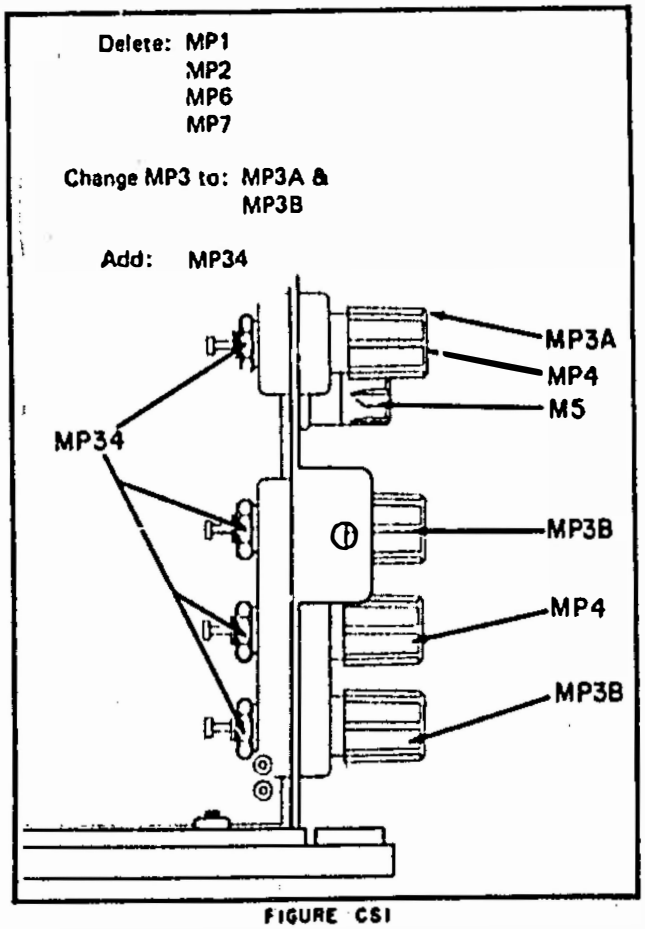


FIGURE CS1

Page 6-6, Table 6-1. Delete the following parts:

MP1	0340-0090
MP2	0340-0086
MP6	0340-0087
MP7	0340-0091

Change the part numbers for the following reference designator:

	From	To
MP3	1510-0010	MP3A 1510-0090 TQ1
		MP3B 1510-0091 TQ2
MP4	1510-0011	1510-0107 TQ2
MP12	1510-0035	1510-0087 TQ1
MP13	1510-0036	1510-0084 TQ1
MP14	0340-0099	0340-0732 TQ2
MP15	0340-0160	0340-0732
MP24	00400-00210	00400-00212

Add: MP34 2950-0144 TQ5

CHANGE NO. 3 applies to serial number 0950A-09386 and above for the 400F and serial number 0950A-09406 and above for the 400FL.

Page 6-4, Table 6-1. Change part number and description of A2C28 from 130 pF 0140-0195 to 82 pF 0140-0193 and add a star to reference designator.

Page 7-3/7-4, Figure 7-2. On the schematic place a star next to C28 and change the value to 82 pF.

CHANGE NO. 4 applies to serial numbers 0950A09786 and above for the 400F and serial number 0950A09836 and above for the 400FL.

Page 6-6, Table 6-1. Change the Part Number and Description for MP5 from 1400-0084--Holder:Fuse to 2110-0470--Fuhlr--Extr Post and 2110-0465--Cap.
Add the following part numbers and description as required hardware:

2110-0467	Nut Hex	Qty. 1
1400-0090	Washer	Qty. 1
2190-0054	Washer	Qty. 1

CHANGE NO. 5 applies to serial numbers 0950A10085 and above for the 400F and serial numbers 0950A10036 and above for the 400FL.

Table 6-1 on Pages 6-3, 6-4, 6-5. Change the part numbers for the following reference designators:

	From	To	Description
A2	00400-66504	00400-66514	Same
A2R6	2100-0095	2100-3214	R:Var Comp Lin 100 kΩ ± 10% 0.10 W
A2R68	2100-0277	2100-0568	Res:Var, 100 Ω ± 10% 0.3 W

Page 6-4. Add to A2C37* -hp- part number 0140-0201 the following padding list:

5 pF	500 V	0160-0763
18 pF	300 V	0160-0356

Page 6-5. Add to A2C63* -hp- part number 0698-4458 the following padding list:

499 ohm	.01	0698-4123
681 ohm	.01	0757-0419

Page 7-3/7-4, Figure 7-2. Change A2 board from -hp- part number 00400-66504 to 00400-66514.

CHANGE NO. 6 applies to serial numbers 0950A10206 and above for the 400F and serial numbers 0950A10176 and above for the 400FL.

Page 6-4. Change A2C38, C39 from -hp- part number 0180-0393 to 0180-2795, C:Fxd Ta 39UF ± 10% 10 VDC W.

CHANGE NO. 7 applies to all serial numbers.

Page 1-1. Add the following paragraph between 1-3 and 1-4.

Options.

Option 910. An additional Operating and Service Manual part number 00400-90016.

00467-90003

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